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COMPARATIVE COMMERCIAL VALUES
OF
GAS COALS & CANNELS

DAVID A. GRAHAM

A TREATISE

ON THE

COMPARATIVE COMMERCIAL VALUES

OF

GAS COALS AND CANNELS.

BY

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PREFACE.

In the following treatise on the comparative commercial values of different gas coals and cannels, I have endeavoured, as concisely and clearly as was possible for me, to re-state the principles affecting their values, and illustrating the manner in which they may be applied to actual use.

The method I formerly recommended, I have considerably simplified, using tables in one instance where I previously resorted to calculation. I have also substituted constants for proportion, and have further given a few examples where the more tedious portion of the calculations are estimated with the aid of logarithms, so that the whole process of estimating the sum of the values of the various products produced from gas coals and cannels has been considerably abbreviated, with no sacrifice as to accuracy of results, but rather the reverse.

At the end of the book, two graphic delineations of the value per 1000 of the various qualities of gas produced from the first and second series of valuations, are given, from which I have deduced another simple method of valuing the gas produced from coals and cannels.

I need not here dilate on the importance of this question to those interested in the financial success of gas undertakings. Years ago, when challenged to prove that an inferior quality of coal here referred to was comparatively worthless for gas manufacturing purposes, I had then no means of substantiating the statement, nor of refuting an opposite opinion. I now submit a method of ascertaining the comparative commercial value of coals and cannels, which I believe will be useful, as tending to encircle with law and rule, one of the most important of the many questions connected with the economics of gas manufacture.

At the end of the papers treating of coal and cannel valuation, I have added one treating of the method of ascertaining the cost of adding a candle to the illuminating power of gas, which may also prove serviceable.

I trust the methods of valuing I have here recommended and illustrated, may, when occasion requires, be found available, to those who may have occasion to resort to some such mode of computing the comparative commercial values of different qualities, and variously priced materials for gas manufacturing purposes. The methods here given and illustrated may be varied to suit any particular case, although the tables, constants, &c., &c., will in each instance have to be calculated so as to meet the wants and circumstances of that particular district or place.

And now, after intermittently devoting my attention to a consideration of this subject during some of my leisure hours for several years past, I take leave of the subject, not without a hope, that, in a measure, my efforts may, to some extent, prove successful, in bringing to a solution a question which must be deeply interesting to those who are directly or indirectly connected with gas undertakings.

DAVID ALLAN GRAHAM,
Engineer.

LONDON, *May* 1882.

ERRATUM.

Page 34. In valuation, for 1*s*. 10¾*d*. read 2*s*.

A TREATISE
ON THE
COMPARATIVE COMMERCIAL VALUES OF GAS COALS AND CANNELS.

AN INQUIRY INTO A METHOD OF ASCERTAINING THE RELATIVE COMMERCIAL VALUES OF DIFFERENT QUALITIES OF GAS COALS AND CANNELS.

THE question we propose to discuss in the following pages

the coal or cannel whose qualities will best satisfy all the con-

ERRATA.

Page 10. *For* "included in his valuation," *read* "included in this valuation."
Page 16. *For* "found from the olution," *read* "found from the solution."
Page 56. *For* "states that cannel," *read* "states that (———) cannel."
Page 60. Below Log. of 100
the sum equals 7·64769493
Log. 630720 = 5·79983360
Log. 70·447 = 1·84786133
Page 96. *For* "16*s*. delivered," *read* "15*s*. 9*d*. delivered."
In Plate 2. Fig. 9. *For* "+ 131·5 candles," *read* + "131·5 pence."

ditions most conducive to economic working, together with proportionate lowness of price, will necessarily be that which will enable gas of standard quality to be manufactured at the minimum of costs to the consumer, and the maximum of profit to the manufacturer.

Without descending too minutely into minutia and detail, the following catalogue of particulars will embrace the principal items and products, whose values affect and determine the relative values of different qualities of gas coals and cannels.

These are:—

A. The quantity of gas in cubic feet, or stated in terms of any other convenient measure of capacity or volume—per ton—or in terms of any other convenient unit of weight, this particular sample of coal or cannel will produce.

B. The illuminating power of the gas produced, stated in terms of some *uniform standard* of illuminating power, such as the standard candle, or other statutory or arbitrarily chosen standard of measure, selected for ascertaining the relative illuminating powers, of different qualities of gas, these qualities also being measured and expressed in terms of some burner chosen to ascertain or express this illuminating power for all qualities of gas. This value being ascertained equationally for illuminating powers which the burner would be found incapable of measuring, except by using such gas diluted with some other known quality and quantity from which the illuminating power of the gas whose illuminating power is sought can be determined.

C. The weight in pounds of red-hot unslaked coke a ton of coal or cannel will produce—the percentage of ash this coke contains; together with the evaporative power of this coke as ascertained in furnaces heating boilers open to the atmosphere, and so constructed as to be suitable for ascertaining this value.

D. The weight in pounds, and the strength of the ammoniacal liquor produced from a ton of material, stated in terms of Twaddel's hydrometer, or in ounces of sulphuric acid, together with the weight of carbonic acid and sulphuretted hydrogen present in the production of liquor from a ton of the coal or cannel.

E. The weight of tar in pounds a ton of coal or cannel produces, together with its fractional analysis obtained by distillation—giving the weight of pitch; naphtha; or other valuable constituents present, and the weight of such other products as anthracine, or other dye; which may tend greatly to enhance its value.

F. The volume—or preferably the weight of carbonic oxide present in the gas, and whether this may not be partly due to the laminations of vegetable charcoal sometimes present in the coal (as is the case with some qualities raised at Newcastle, N. S. W., used for gas manufacturing purposes, and not unfrequently in this country as well), a cause separable from retaining a charge of coal or cannel—converted into coke during the process of carbonizing—too long in the retorts. Thereby roasting the red hot coke, which then disengages considerable quantities of carbonic oxide (leaky retorts and excessive exhaust may be made to produce a similar result from the imperfect combustion of the furnace gases, which is of course a cause distinguishable from carbonic oxide in the gas generated in the retorts).

G. The carbonic acid present in the whole of the *crude* gas produced from a ton of coal or cannel.

H. The sulphur compounds, sulphuretted hydrogen, and bi- or di-sulphide of carbon present in the gas a ton of coal or cannel produces.

In estimating and allowing for the difference of the costs of purification for different qualities of gas coals and cannels, that is the cost of removing the carbonic acid, sulphuretted hydrogen, and bi-sulphide of carbon, which remain in the crude gas, after a portion of these impurities have been removed, while the crude gas was in contact with the ammoniacal liquor, the better way seems to be to ascertain the number of pounds and the fraction of a pound of anhydrous or unslaked lime, requisite to purify 1000 cubic feet, or by preference the whole of the gas produced from a ton of the coal or cannel submitted for purchase and valuation. The weights of lime required to effect purification as set forth in some tables of analysis, are not infrequently much in excess of the quantities required in actual practice. This is in some cases doubtless due to the fact, that in practical working, the lime is thoroughly exhausted, not fewer than three out of four purifiers being used; whereas, for experimental work, *one purifier* is not infrequently used, which is changed or renewed for another, as soon as it begins to foul, and thus the return is *much* in excess of results obtained practically.

The inlet area of a system of purifiers ought not to be less than *one superficial foot* for each 1000 cubic feet of gas, passed through them per 24 hours, a rule I published some eight years ago, when reporting on the condition of Macclesfield Gas Works.

The cost of lime and labour being known for each individual case, it would be easy to include the *difference* of these costs in any valuation. For instance, suppose that in a particular case it required 100 lbs. of lime to purify the 10,000 cubic feet produced, from some particular coal or cannel, and that the costs for lime and labour equalled ¾*d.* or 0·75*d.* per 1000, equal to 7·5*d.* or 7½*d.* per ton, or per 10,000 cubic feet for this material, and that another coal or cannel producing 10,500 cubic feet required 120 lbs. of lime to effect its purification. Then these two costs, lime and wages, are to be estimated for *conjointly.* And the differences in costs for purification are to be ascertained as follows:—

First ascertain this cost per 100 lbs. of anhydrous or unslaked lime, which we shall in this case assume to be 7·5*d.* Then, should a coal or cannel require only 80 lbs. to purify the gas it produced, while another required 120 lbs., the difference between 120 × 7·5*d.* and 80 × 7·5*d.* would give the value required, equal 9*d.* − 6*d.* = a difference of 3*d.* I have, unfortunately not been able to include this charge in all of the following valuations, as the apparatus with which I made these analyses was not fitted up with more than one purifier.

We shall now proceed to inquire seriatim into how these several primary and secondary products, together with the impurities enumerated, affect the commercial values of gas coals and cannels.

First, then,

A. THE QUANTITY IN CUBIC FEET A TON OF COAL OR CANNEL WILL PRODUCE.

The volume or quantity of purified gas a ton of coal or cannel will produce, is doubtless *considerably* in excess of the quantity obtained from actual practical working, and theoretically may be defined as that quantity or volume, which would be generated by such a destructive distillation of the coal or cannel at high heáts, as would render the whole of the hydrocarbon compounds capable of being rendered gaseous, into permanent gas, less the carbonic oxide, a product of heated coke, and of some coals used for gas manufacturing purposes, containing laminations of vegetable charcoal, but here too principally produced during the end of the duration of a charge, when the freed oxygen unites with the carbon to form carbonic acid, carbonic oxide, or with hydrogen to form water. Carbonic oxide is an impurity which is *not* removed by present means of purification, but it is prevented from being generated in quantity, by limiting the duration of the charge, and thus avoiding its being diffused through the hydrocarbon gaseous products.*

The percentages of hydrogen, marsh-gas, heavy hydrocarbon, and olefiant gas generated from the same materials at different temperatures, does not concern us in the present inquiry. We leave this for the chemist. But the report of a test of gas coals and cannels should manifestly present a fair statement as between colliery proprietors and gas committees, of the several products the coal or cannel submitted for purchase produces.

If *fairly sampled*, how is this to be done?

Dr. Siemens has recently stated, *vide* 'Nineteenth Century,' paper on "The Sun," that the temperature at which certain gases are decomposed or chemically disassociated from each other, as stated by Bunsen and Sainte-Claire Deville, or to quote his language: "The point of decomposition of different compounds depends upon the temperature on the one hand, and the pressure on the other. According to Sainte-Claire Deville the disassociation tension of aqueous vapour at atmospheric pressure and 2800° C. is 0·5, that is, one half of the vapour would exist as such, the remaining half having formed a mechanical mixture of oxygen and hydrogen." The temperatures for the disassociation of hydrocarbon vapours are not given, but temperatures much less intense than this would prove destructive to the life of a retort, whose internal working temperature equals 2150° Fahrenheit, a temperature which may possibly decompose some of the constituent gases; leaving deposits of sooty carbon in the ascension pipes, scurf in the retorts, and liberating the combined hydrogen.

---

* Carbonic oxide might yet form one of the products sold by Gas Companies, which would give coke and breeze a new value, if the whole or part of the oxygen required were obtained from the decomposition of water by electricity, or otherwise, the resulting combustion temperature, after this gas had been cooled down for distribution, would be high, and such gas could possibly be sold for 3*d.* per 1000.

In laboratory experiments, where the 1000th, or 500th part of a ton is experimented on, and when the duration of the charge does not exceed three or four hours, the coal or cannel is subjected to a high heat, and lies in a *thin* layer on the bottom of the retort, enabling the gas, during the disintegration of the coal to be liberated from the centre of its mass much more freely than is usually the case with practical working, and six hours' charging; in the latter case some products which would be rendered gaseous in the small experimental retort, are in the larger one converted into tar. The consequence is that large results are usually obtained, more especially as regards *volume*, with experimental working, as, for instance, in a case with which we are familiar, there is an excess of 10 per cent. in both makes and illuminating power in the laboratory experiments as compared with the best practical working from the same material used dry, which is equal to a decrease of 19 per cent. on the two taken conjointly, thus—

$$\begin{array}{r} 10{,}000 \times 10 = 100 \\ 9{,}000 \times 9 = 81 \\ \hline \end{array}$$

19 per cent.

So that laboratory tests may be said to exceed practical tests by 20 per cent. But with coal liable to be exposed to wet, the disparity would of course be greater.

Are laboratory experiments then, frequently made from *picked samples*, to form the basis from which the commercial value of any particular quality of coal or cannel are to be estimated?

The fact of the matter is, few gas managers place much confidence in reports which are not drawn up by themselves. Is it then a question of *ratio*? If *all* were valued from this exaggerated basis, would not the *proportional* result be the same?

This specious method of reasoning is not altogether applicable to practical matters, involving financial success or loss, the tenth part of a ton, equal to 224 lbs., would be a little enough quantity of material to experiment on for a charge, and would give a more satisfactory *average* result—a mean between practical working results, and those obtained from testing small quantities. For purposes of *commercial* valuation, the volume of gas produced from a ton of coal or cannel will be that quantity which will be obtained from carbonizing a reasonably large quantity of the material to be tested, in a good sound retort, raised to a fair heat, the coke being withdrawn as soon as it becomes heated to redness, and ceases to give off other than carbonic acid, or carbonic oxide gas, or hydrocarbons of very low illuminating power, a condition usually obtained by retaining a charge in a retort from three and four to six hours; the best results being those which are obtained from the highest numbers found by multiplying the quantity produced in cubic feet by the quality of the gas produced in candles: thus 10,000 × 15 candles = 150, would give a better result than 11,000 × 12 candles = 132,—carbonic oxide, or hydrocarbons of low illuminating power, reducing the resulting integers to a less number than the result giving the lesser production of cubic feet of gas per ton, but a larger illuminating power; a rule which may prove serviceable for practical economic working, and one applicable to several other purposes in gas manufacture.

In a gasworks it is necessary daily to produce such a quantity of gas, continually varying with the season of the year, weather or other conditions, as shall adequately supply the daily wants of the public.

It will consequently require less of a rich coal or cannel producing a large volume of gas to supply the public wants and demands, than if this gas had to be supplied from coals or cannels yielding a small return per ton. Thus, if the production were half as much per ton in one case as it was in another, where a better class of material was used, *double* the number of retorts would require to be kept in use, double the carbonizing wages would be paid. The wear and tear would be doubled. The size of the retort house would be doubled. The coke used for firing would be doubled. The capital expended for retort houses and settings would be doubled. The interest for the same would also be doubled. The cost of repairs and renewals would also be doubled. All of which items, favourably or unfavourably, affect the commercial value of gas coals and cannels.

For a quality of coal or cannel producing, say 10,000 cubic feet per ton, the stokers' wages in one particular case, representative of a number of others, would equal 2*s.* 4½*d.* per ton of coal or cannel carbonized, which includes wheeling the coal to the retorts, charging, drawing, and firing, cleaning fires, and wheeling the coke out of the retort house.

The fuel used in a setting of retorts, should be valued at the average price of the whole of the year's, or preceding year's sales, and in the following valuations it will be assumed to be worth 6*d.* per 100 lbs., equal to 11*s.* 2¼*d.* per ton. The value of secondary products in such computations as these, being more easily ascertained per 100 lbs., which is also *now* a legal weight, and is denominated a cental.

The weight of coke used in the furnace of a retort setting we shall estimate at one-fifth of the weight of coal carbonized, which is probably nearly the weight of best gas coke required for firing purposes in a well-set bed of retorts, being equal to 20 per cent. of the weight of coal carbonized, and would equal 448 lbs. for each ton of coal or cannel carbonized. The cost for coke for firing per ton carbonized would therefore equal 4·48 × 6*d.* = 2*s.* 3*d.*

In valuing the receipts for gas and the secondary products a ton of coal or cannel produces, the values should all be compared with the quantity of gas per ton as measured at the station meter, the question of leakage being one which is not involved in the consideration of this question.

In a Lancashire town, a setting of retorts is on the average required to carbonize from 800 to 1000 tons of coal and cannel per annum. A setting of retorts, with connections, roofing, and walls complete, will cost about £500, 10 per cent. on which amount equals £50, which, divided by 1000 tons, equals 1*s.* per ton for interest on each setting of retorts; it will be evident that the poorer the quality or productive power of the coal or cannel used, the greater must be the number of retort settings in use, so must the interest charged be proportionately increased for working the poor coal as compared with the richer one, and in a comparative valuation, this difference resolves itself into a charge against the poorer material. The cost of renewals and repairs (a setting such as the one indicated, five retorts, will carbonize from 5 tons 5 cwts.; to 6 tons 6 cwts. per day of 24 hours)[*] of retort settings may here be taken at the same amount as the interest charged per ton for settings, namely at 1*s.* per ton of coal and cannel carbonized. These several charges will therefore, in the aggregate, amount to 6*s.* 8*d.*, equal 6·666*d.*

	s.	*d.*
448 lbs. of coke used for fuel at 11*s.* 2½*d.* per ton ..	2	3
Stokers' wages, at 2*s.* 5*d.* per ton carbonized	2	5
Interest for use of settings, at 1*s.* per ton carbonized	1	0
Repairs and renewals, at 1*s.* per ton carbonized ..	1	0
Together making the charge of	6	8

Now as only a certain definite quantity of gas was required to be manufactured, it would require less of a richer coal or cannel, producing, say, 11,000 cubic feet per ton to produce this quantity of gas, than that poorer quality producing 10,000 cubic feet. $\frac{6\cdot666 \times 10}{11} = 6\cdot0606$ shillings, would therefore represent the value of those charges for a coal or cannel or a mixture of both, producing 11,000 cubic feet: for one producing 9000 cubic feet, they would amount to $\frac{6\cdot666 \times 10}{9} = 7\cdot4$.

---

[*] These retorts are 20 feet long, by 24 inches across.

The following table, based on these costs for 10,000, namely 6*s.* 8*d.*, gives the rise in cubic feet for these costs corresponding to each rise of 1*d.* between 7000 cubic feet and 16,666 cubic feet, and the annexed diagram (Fig. 5) shows graphically the same results, for whole number makes between 7000 and 16,000 cubic feet.

It might be thought that the coke should not be included in his valuation at one constant price for all these makes, inasmuch as for coals yielding inferior makes, the quantity of coke produced must necessarily be much larger, and as the market must be correspondingly glutted—the supply increased for no increase in demand—the price realised will be less, at least, in winter. But if it be remembered that a larger quantity of the inferior quality will be required for firing, that there will be a corresponding increase in clinkering, besides that due to inferior coke made from inferior coal, then it will be apparent, especially as makes must also, or may be, affected as well. That for these reasons it will be seen we have fallen into no error in valuing the whole coke used for firing at one uniform price, a principle which also equitably affects the value of coals giving large productions (makes) per ton. We shall here illustrate how this table is to be applied to actual use.

One coal produces 10,666 cubic feet, while another produces 8,320. The tabular costs for the former, equals 6*s.* 3*d.*; for the latter, equals 8*s.*, a difference of 1*s.* 9*d.* In the one case the colliery proprietor's coal or cannel (*in the valuation,*) gets the benefit of this 1*s.* 9*d.*, and it is paid to him in consideration of the superior productive quality of his coal; in the other case it is a charge *against* the coal as this 1*s.* 9*d.* has to be paid either for the superior coal, or the gas company must meet this charge by an equivalent outlay in wages, interest for capital, fuel and repairs, if the inferior one be used instead. It will be observed that it is the *difference* in these charges, for differences in makes *only*, which is taken into account in these computations. The reason will be apparent. The difference is that which is necessarily paid for in *any* case, and which must be provided for; wages must be paid, capital must be raised, interest should be paid on it. Fuel must be used, but excesses which arise from the use of inferior material are a charge against such material. This inferior material may be used profitably, but only *at a price*, a price which involves no loss, but a higher, or as much profit.

s.	*d.*			*s.*	*d.*		
4	0	4·0	16·666	6	0	6·0	11·111
4	1	4·0833	16·326	6	1	6·0833	10·958
4	2	4·1666	16·000	6	2	6·1666	10·810
4	3	4·25	15·686	6	3	6·25	10·666
4	4	4·3333	15·384	6	4	6·3333	10·526
4	5	4·4166	15·094	6	5	6·4166	10·399
4	6	4·5	14·814	6	6	6·5	10·256
4	7	4·5833	14·567	6	7	6·5833	10·126
4	8	4·6666	14·286	6	8	6·6666	10·000
4	9	4·75	14·035	6	9	6·75	9·876
4	10	4·8333	13·793	6	10	6·8333	9·756
4	11	4·9166	13·559	6	11	6·9166	9·639
5	0	5·0	13·333	7	0	7·0	9·523
5	1	5·0883	13·115	7	1	7·08333	9·390
5	2	5·1666	12·903	7	2	7·16666	9·302
5	3	5·25	12·717	7	3	7·25	9·195
5	4	5·3333	12·500	7	4	7·3333	9·090
5	5	5·4166	12·310	7	5	7·4166	8·988
5	6	5·5	12·121	7	6	7·5	8·888
5	7	5·5833	11·940	7	7	7·58333	8·791
5	8	5·6666	11·764	7	8	7·6666	8·695
5	9	5·75	11·594	7	9	7·75	8·602
5	10	5·8333	11·428	7	10	7·8333	8·513
5	11	5·9166	11·270	7	11	7·9166	8·421

s.	*d.*			*s.*	*d.*		
8	0	8·0	8·333	8	10	8·8333	7·547
8	1	8·08333	8·228	8	11	8·9166	7·476
8	2	8·16666	8·163	9	0	9·0	7·407
8	3	8·25	8·080	9	1	9·0833	7·339
8	4	8·3333	8·000	9	2	9·1666	7·272
8	5	8·4666	7·920	9	3	9·25	7·207
8	6	8·5	7·841	9	4	9·3333	7·142
8	7	8·58333	7·767	9	5	9·41666	7·080
8	8	8·6666	7·692	9	6	9·5	7·016
8	9	8·75	7·61	9	7	9·58333	6·956

It must be understood that we are here treating of a principle. The practice must, of course, in all cases be altered so as to conform to the requirements of the particular case. The figures here given are more applicable to some Lancashire towns, but wherever different costs for these and all following values are computed, they should in each case be made applicable to the peculiar circumstances, and the costs current for that district; but in any case, when these costs are ascertained, a table similar to the one supplied can speedily be calculated by means of logarithms, or by the longer method of actual division, by computing this charge in any particular case for a coal producing 10,000 cubic feet, and dividing it successively by all prices intermediate between the limits chosen, in this case between 7000 and 16,666 cubic feet.

B. Illuminating Power.

And now we shall proceed to consider the question of Illuminating Power, and its relation to the commercial values of gas coals and cannels.

Coals and cannels may be said to possess a considerable variety of illuminating powers, varying with the burner used. The rate of burning, and the pressure at which the gas is delivered at the burner. Gas companies using high illuminating powers, testing with bat's-wings, fish-tails, or other suitable burner, specified by statute, while those manufacturing common gas in some cases use the older forms of Argand, as stipulated by older Acts of Parliament, or in other cases, the more modern description of burner known as Sugg's Referee's London Argand.

The choice of burner must of necessity affect the results obtained.

The illuminating power of cannel gas, as ascertained in a bat's-wing, flat-flame, or fish-tail, will, in all probability, differ from the result obtained when a percentage of the same gas is used along with common coal gas, and in this latter case the readings will generally be larger or higher than the results obtained from the bat's-wing. The burners of most recent construction such as Sugg's, Siemens', Bray's, &c., may doubtless give better results than any specified by metropolitan or provincial Acts of Parliament, and they will give higher illuminating power for similar qualities of gas, but for valuing the gas produced (commercially) in a cannel, the result should be given not only in terms of the bat's-wing, or of the other test burner for burning that quality of gas, but also in terms of the burner selected arbitrarily from among burners for testing commoner qualities of gas. The value in this case might be denominated the *equational* illuminating power of cannel gases, expressed in terms of the standard burner used for ascertaining the quality of common coal gas for purposes of public illumination.

The illuminating power of cannel gas should therefore be expressed in terms of some statutory burner suitable for burning it by itself, such as a bat's-wing, and also in terms of some such burner as Sugg's Referee's London Standard Argand.

High illuminating powers are generally being abandoned, while low ones are as generally being raised, so that for purposes of the *commercial* valuation of gas coals and cannels it is this *equational* value of the illuminating power of the gas which should be taken into account, when we assign a money value to the illuminating power produced, and inasmuch as the coal and cannel gases thus reported on, from their use in a burner which can be made applicable for ascertaining the illuminating powers of both; we shall hereafter assume that it is this *equational illuminating power* which has been obtained in all cases for cannels, to be made applicable for the commercial valuation of the gas they produce; and now as to how this *equational* value of illuminating powers for cannels may be obtained, and a definition of what it is when found.

The equational illuminating power of cannel gas is that illuminating power found from using an equational formula, for finding the illuminating power the gas produces, *when used along with a certain known quantity of common coal gas* (or hydrogen), whose illuminating power has already been ascertained, and can be allowed and estimated for in the mixture. We have not heard of hydrogen gas being used for the obtaining of this value; but from the facility with which it could be produced by decomposing water with electricity, taken together with the fact that it burns with no illuminating power, it seems to be an extremely suitable means for obtaining this illuminating power, with a greater certainty of accuracy than when coal gas is used for a similar purpose. Thus, suppose. 100 volumes in any particular cubic measure of a mixture of hydrogen, and cannel gas, were burnt in Sugg's London Standard Argand Burner, and that it gave an illuminating power of say 15 candles, and suppose fifty volumes of this mixture consisted of *hydrogen*, which has no illuminating power, and that the other fifty consisted of the cannel gas to be tested and reported upon; then it is evident that the cannel gas would produce 30-candle gas as measured by that particular burner—if two-thirds hydrogen were used in the mixture, the illuminating power of the cannel gas would be reduced to one-third of its actual value, in the case of 30-candle gas to 10 candles, and if one-third the volume of hydrogen were used for two-thirds the volume of cannel gas, the illuminating power would be reduced by one-third. Twenty-one-candle gas would be burnt with the hydrogen as 14-candle gas, and so on for other proportions.

Where gas of low illuminating powers may be preferred, the equational illuminating power a cannel gas produces may be found as follows.

A mixture of 50 per cent. of coal gas, plus 50 per cent. of cannel gas, when tested with Sugg's Standard London Argand burner, gave an illuminating power equal to 18½-candle gas. The illuminating power of the coal gas when tested *alone*, was found to be equal to twelve candles—what was the illuminating power of the cannel gas in terms of Sugg's S. L. A. B. Let I represent the illuminating power of the cannel gas, and *i* the illuminating power of the coal gas. Then generally I × percentage of cannel gas + *i* × percentage of coal gas = illuminating power × 100 per cent. of the mixture, as in the case supposed.

$$\begin{aligned} (\mathrm{I} \times 50) + (i \text{ or } 12 \times 50) &= 100 \times 18\cdot5 \\ (\mathrm{I} \times 50) + \quad 600 \quad &= 1850 \\ \text{Therefore} \qquad \mathrm{I} \quad &= \frac{1850 - 600}{50} \end{aligned}$$

$$\text{Therefore } \mathrm{I} = 25 \text{ candles.}$$

Or again, 100 per cent. of a mixture of common and cannel gas produced 17·25 candles. The mixture contained 66·66 per cent. of coal gas, whose illuminating power when tested by itself was equal to 13·75 candles. Then

$$\begin{aligned} (\mathrm{I} \times 33\cdot33) + (i \text{ or } 13\cdot75 \times 66\cdot66) &= 100 \times 17\cdot25 \\ (\mathrm{I} \times 33\cdot33) + 916\cdot575 \qquad &= 1725 \\ &= \frac{1725 - 916\cdot575}{33\cdot33} \end{aligned}$$

$$\therefore \mathrm{I} = 24\cdot35 \text{ candles.}$$

So that the illuminating power of this cannel gas stated in terms of Sugg's S. L. A. burner, as found by this equational method, equals 24·35 candles, and it is this result, obtained from testing by means of the standard burner, which at the time, and by general consent, is looked upon as the standard burner for such illuminating powers as 16-, 17- and 18-candle gas, which is to be taken as giving that illuminating power suitable for computing the commercial values of different qualities of cannel gas —*except* in cases where high illuminating powers are used by the public, when the illuminating power of the cannel as tested by a bat's-wing, or other suitable burner is to be substituted, although such cases are likely to become rarer every day.

The burner hereinafter referred to will therefore be Sugg's Standard London Argand, containing 24 holes, each 0·045 in. diameter. The steatite top having an internal diameter equal to 0·840 in., an internal one of 0·480, and a chimney for 16-candle gas, 6 inches high by $1\frac{7}{8}$ in. internal diameter.

It will be most convenient here to advert to an equational method of ascertaining the approximate makes and illuminating powers of coals and cannels; where the coal or cannel with which the material to be tested, is found to be comparatively uniform in quality, and when its illuminating power and production per ton are known. In the following case let us assume that 42·55 per cent. of a coal is used which produces 9000 cubic feet of 12-candle gas, together with 57·45 per cent. by weight of a cannel whose illuminating power and its return per ton are unknown, but that the mixture produces 9572·2 cubic feet per ton, and that the illuminating power of the mixture equals 18 candles, and let R stand for the return per ton, and I the illuminating power of the gas produced from this cannel. Then

$$(9000 \times 12 \times 42 \cdot 55) + (R \times I \times 57 \cdot 45) = 100 \times 18 \times 9572 \cdot 5.$$

First find R, the return per ton of the cannel, which will be found from the olution of the following equation :—

$$(9000 \times 42 \cdot 55) + (R \times 57 \cdot 45) = 100 \times 9572 \cdot 5$$

$$\text{or } (382950) + (R \times 57 \cdot 45) = 957250$$

$$R \times 57 \cdot 45 = 957250 - 382950 = 574300$$

$$\therefore \; R = \frac{574300}{57 \cdot 45} = 10{,}000 \text{ cubic feet nearly.}$$

Substitute this value of R 10,000 cubic feet for its symbol in the equation and it becomes,

$$(9000 \times 12 \times 42 \cdot 55) + (10{,}000 \times I \times 57 \cdot 45) = 100 \times 18 \times 9572 \cdot 5$$

an equation containing only one unknown quantity, I, the illuminating power this cannel will produce,—then

$$(4595400) \times (574500 \times I) = 17230500$$

$$\therefore 574500 \times I = 17230500 - 4595400 = 12635100$$

$$\therefore \; I = \frac{12635100}{574500} = 22 \text{ candles.}$$

Therefore this cannel produces 10,000 cubic feet of 22-candle gas.

A mixture of 50 per cent. of coal and 50 per cent. of cannel produces 9777 cubic feet of 18·5-candle gas, the cannel (W Y) was found to produce 10,033 cubic feet of 21·3-candle gas, how much did this coal (W R and R ') produce to the ton? and what was the illuminating power of the gas?

Let r = the return per ton of the coal, and i the illuminating power of the gas it would produce. Then $(r \times i \times 50) + (10{\cdot}033 \times 21{\cdot}3 \times 50) = 9777 \times 18{\cdot}5 \times 100$.

First find r, the return per ton of the coal.

$$
\begin{aligned}
(r \times 50) + (10{,}030 \times 50) &= 9777 \times 100 \\
(r \times 50) + \quad 501650 \quad &= 977700 \\
\therefore\ r \times 50 = 977700 - 501650 &= 476150 \\
\therefore\ r = \frac{476150}{50} &= 9523 \text{ cubic feet.}
\end{aligned}
$$

Restate the original equation, substituting the value of r for its symbol; then,

$$
\begin{aligned}
(9523 \times i \times 50) + (10033 \times 21{\cdot}3 \times 50) &= 9777 \times 18{\cdot}5 + 100 \\
\text{or } (476150 \times i) + 10685146 &= 17087450 \\
\therefore\ 476150 \times i = 17087450 - 10685146 &= 6402304 \\
\therefore\ i = \frac{6402304}{476150} &= 13{\cdot}4\text{-candle gas.}
\end{aligned}
$$

This coal therefore produces 9523 cubic feet of 13·4 candle gas, results which nearly approximate to those obtained when this coal was tested separately in a testing apparatus.

The coal and cannel gas are here tested together in the burner, which is thus made a means of measuring the illuminating power of both. If the coal and cannel are charged in separate retorts the effect will be much the same as blending and diffusing the two gases separately. When the coal and cannel are mixed in the same retort, the chemical effect produced, such as the composition and percentages of the constituent gases may vary from that produced by a diffusion of the two after being produced separately. We have not seen a chemical analysis of the two methods of working, and shall therefore venture no remarks as to their separate effects.

There are several items in connection with this question of comparative commercial values in which illuminating power and the production per ton are to be considered conjointly; and here at the outset, let us disabuse our minds of a fallacy which has obtained some currency—*quality* multiplied by quantity, although a useful number for certain purposes, is not to be confounded with a method hereafter to be described and illustrated for ascertaining the relative commercial values of the gas produced from gas coals and cannels. Thus, supposing a coal produces 10,000 cubic feet of 12 candle gas, and a cannel produces 12,000 cubic feet of 20-candle gas, then the cost of this 10 × 12 = 120 candles per 1000, *is not* to be taken as a measure of the commercial value of the gas produced from any other coal or cannel, as for instance of this 12 × 20 = 240 candles per 1000 produced from the cannel. The object to be attained by a comparative valuation of different qualities of coals and cannels is to know in difficult cases, or in any case, from what material gas can be manufactured in any particular district at the cheapest rate commensurate with legitimate profit, and the maintenance of the standard quality of gas. Circumstances affect the value of gas coals and cannels, such as the competition of the general public with the gas companies, thus tending to raise the value of certain coals above the price a gas company might in certain cases be able to manufacture gas from, economically; no arbitrary artificial value can therefore be assigned to the candle per thousand, applicable to the valuation of the gas produced from any variety of material—as a rule the cannel candle costs *more* in the cannel than in the coal—dependent upon its greater rarity; what is to be sought for is a *choice*, or a method of choosing and ascertaining *among a variety* of *coals and cannels*, that which *is selling at such a price* as will leave the largest margin for profit at the lowest remunerative price at which gas can in that district be sold. We have here digressed to combat such a statement as we have seen somewhere. "In the Wigan district a candle per thousand may at present be considered as worth *x*, we forget the amount. To say that *x* is the value of the candle per 1000 in a particular case may be correct;

but to make this a measure for all the candles per 1000 produced from other coals or cannels is absurd and inaccurate—a fallacy which we trust to be able to exemplify as we proceed. And now we come to treat of a method which will enable us to determine the comparative values of gas produced from different qualities of coal or cannel, with as great accuracy as we believe it is possible to attain to in matters of this kind.

In 'The Journal of Gas Lighting' and in the first edition of a pamphlet treating on this subject, I gave a graphic representation of a method of ascertaining the illuminating power, and the makes produced from mixtures of coal and cannel intermediate to the limits produced from either. To those who are curious on this subject I have at the end added a paper treating of graphic methods of representing makes and illuminating powers.

We are here stating only what seems absolutely essential for the consideration of the question under discussion, and shall therefore only give the rule and the formulæ, an adaptation of the arithmetical rule of allegation, which will enable us to ascertain the percentages of coal or cannel requisite to manufacture any quality of gas intermediate to the qualities the coal or cannel will separately produce, as also the makes which will correspond to this intermediate quality of gas, and which will be found from the following rules.

At the end of the book one diagram represents graphically the results obtained from various qualities and prices of gas per 1000 as contained in the first series of valuations, from which another and *very simple* method of valuing the gas in coal has been deduced.

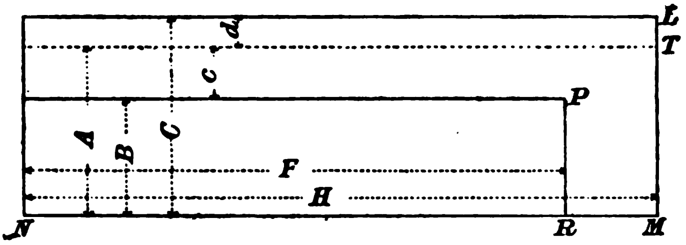
RULE FOR FINDING THE MAKES AND PERCENTAGE OF COAL AND CANNEL REQUIRED TO BE USED TO MANUFACTURE A QUANTITY OF GAS INTERMEDIATE TO THE QUALITY PRODUCED BY EITHER OF THE MATERIALS TO BE USED IN THE MIXTURE.

Find the difference between the illuminating power of the gas produced by the coal, and the quality required to be produced, and find the same value for the cannel. State this difference of illuminating powers for the *coal opposite* the illuminating power of the cannel, and the difference between the illuminating power of the *cannel* and the illuminating power required to be produced, opposite the illuminating power of the coal. Then these two numbers will represent the numerators of fractions whose denominators are the values of the returns per ton the coal and cannel will severally produce. These returns per ton representing the *denominators* of these fractions being placed under these crossed numerators—but opposite to the illuminating power corresponding to these returns per ton. Reduce these two vulgar fractions to their least common measure, after bringing both fractions to a common denominator. Then will their sum (the sum of the numerators) be to any one of them, as 100 is to x, and $100 - x$ will give the other value y, from which percentages the corresponding values of the returns per ton may be obtained by multiplying these numbers (percentages) by the returns per ton for each, and adding the results for their common return per ton.

The following formula will give expression to the foregoing method of computing the values of these percentages, and the returns per ton a mixture of these percentages will produce.

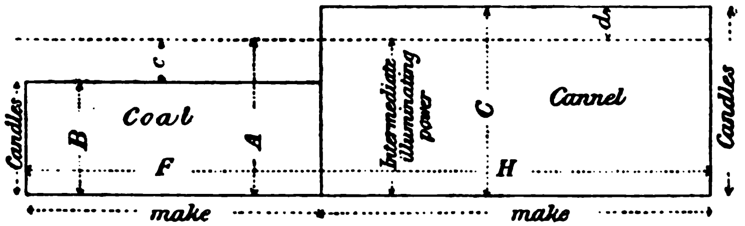
Let N R = the make of the coal, N M the make of the cannel, P R the illuminating power of the coal, and M L the illuminating power of the cannel, and let M T = the intermediate illuminating power required to be manufactured from the mixture. Then in the formulas $M T = A$, $P R = B$, $L M = C$, $A - B = c$, and $C - A = d$, F = make of coal, and H = the make of cannel. Then graphically, N P will = the make × the illuminating power of the coal, and N L the make × the illuminating power of the cannel.

See Figure.



Otherwise

Let A equal the intermediate value of the gas it is desired to produce, B the value of the quality of the gas produced from the coal, and C the value of the quality of the gas produced from the cannel. Then,



$$\begin{array}{lcl}\text{let } A - B & \times & d \\ \text{and } A - C & & c\end{array}$$

Further let the production per ton of the coal producing an illuminating power equal to $B = F$, and the production per ton of the cannel producing an illuminating power equal to $C = H$.

Then will $\frac{d}{F} + \frac{c}{H}$ = the sum of the values of the proportions of the mixtures of coal and cannel requisite to produce that particular quality of gas A.

$$\text{Now} \frac{d}{F} + \frac{c}{H} = \frac{d\,H}{F\,H} + \frac{c\,F}{F\,H}$$

and $d\,H + c\,F$ will equal the sum of those two numerators, and $(d\,H + c\,F) : 100 :: d\,H : x$, $(d\,H)$ being the value of the numerator for the coal, and x the percentage of coal required, or $(d\,H + c\,F) : 100 \;.: c\,F : y$ $c\,F$ being the value of the numerator of the fraction for the cannel required, and y the value of that percentage, and $100 - y$, or $100 - x$, will give the value of the other percentage required.

And x into the return per ton the coal will produce, plus y, or $100 - x$ into the return per ton the cannel will produce, will together give the return per ton the mixture will produce.

I shall now proceed to exemplify the manner in which this rule and these formulas may be applied to practice.

Let it be required to manufacture 18-candle gas from a mixture of coal and cannel. The coal producing 9000 cubic feet of 12-candle gas, and the cannel 10,000 cubic feet of 22-candle gas,

$$\begin{array}{llll} 18 \text{ candles} & - \;12 \text{ candles} & \nearrow & 4 \\ 22 \quad ,, & - \;18 \quad ,, & \searrow & 6 \end{array}$$

$$\begin{array}{rl} \text{and } 4 \times 12 = & 48 \\ 6 \times 22 = & 132 \\ \hline & \text{or } 180 \text{ and } \dfrac{180}{10} = 18 \end{array}$$

(10 here representing the sum of the volumes or cubic feet produced by both), equals 18 candles, so that a mixture of 4 feet, or any multiple of 4 feet of 12-candle gas, plus 6 feet, or 6 feet into the same multiple of 22-candle gas, will together produce 18-candle gas.

We are now required to decide this quantity or volume in relation to the relative makes of the cannel and coal respectively. The coal produced 9000, the cannel 10,000 cubic feet per ton, so that $\frac{4}{9}$ of a ton of coal + $\frac{6}{10}$ of a ton of this cannel = $\frac{40}{90} + \frac{54}{90}$; reducing those vulgar fractions to a common denominator, then $\frac{94}{90}$ of both will produce 18-candle gas, the numerator 40 + 54 expresses the relative weights of coal and cannel, which must be used to produce 18-candle gas, and which are reduced to a percentage, thus: Their sum is to 100 per cent. as any of these numbers is to the percentage to be used.

Thus 40 + 54 : 100 : : 40 : 42·55, and 100 − 42·55 = 57·45.

Therefore 42·55 per cent. of this coal, plus 57·45 per cent. of this cannel, will together produce 9574·5 cubic feet of 18-candle gas.

$$\begin{array}{lrl} \text{For } 42\cdot55 \text{ per cent. of} & 9{,}000 = & 3825\cdot5 \\ 57\cdot45 \text{ per cent. of} & 10{,}000 = & 5745\cdot0 \\ \hline & & 9574\cdot5 \end{array}$$

9574·5 cubic feet with the decimals knocked off.

As a further illustration, let it be required to find the percentages of coal and cannel requisite to produce 15·3-candle gas from a mixture of a coal producing 10,665 cubic feet of 14·3-candle gas, and a cannel producing 9676 cubic feet of 20·3-candle gas.

$$\begin{array}{l} 15\cdot3 - 14\cdot3 \\ 15\cdot3 - 20\cdot3 \end{array} \times \begin{array}{l} 5 \\ 1 \end{array}$$

Then (14·3 × 5) + (20·3 × 1) = 91·8; the sum of the volumes are 6, and $\frac{91\cdot8}{6} = 15\cdot3$ candles. We merely give this as a proof; it is quite unnecessary for making the following estimates:—then $\frac{1}{9676}$ of this cannel + $\frac{5}{10665}$ of a ton of this coal will produce 15·3-candle gas, and

$$\frac{1}{9676} + \frac{5}{10665} = \frac{10665}{103194540} + \frac{48380}{103194540}$$

Then the numerators,

$$10665 + 48380 = 59045 : 100 : : 10665 : x \text{ or } 18\cdot06$$

If logarithms be used, it will be unnecessary to reduce the numerators of the fractions to their lowest terms,

$$\begin{aligned} \text{and } 100 - 18\cdot06 &= 81\cdot94, \text{ and} \\ 81\cdot94 \times 10\cdot665 &= 8738\cdot9 \text{ cubic feet,} \\ \text{and } 18\cdot06 \times 9\cdot676 &= \underline{1747\cdot48} \end{aligned}$$

So that the mixture will produce 10,486·34 cubic feet of 15·3-candle gas.

These two examples, together with the following, may at present suffice to exemplify the practical application of the preceding rules and formulæ. As we proceed, I shall give a few examples, wrought out with the aid of logarithms, which may prove useful to those who should prefer to make part of the calculations more expeditiously, and with less labour than by arithmetical rules.

A coal, G L H, near M, produces 7400 cubic feet of 11·91-candle gas, and a cannel 10,875 cubic feet of 24·25-candle gas, let it be required to manufacture 18-candle gas from mixtures of this coal and cannel, what percentage of each will be required? and what will be the value of the return per ton?

$$\begin{array}{l} 18 - 24\cdot25 \\ 18 - 11\cdot91 \end{array} \times \begin{array}{l} 6\cdot09 \\ 6\cdot25 \end{array}$$

$$\frac{609}{10875} + \frac{625}{7400} = \frac{4506600}{80475000} + \frac{6796875}{80475000}$$

and 4506600 + 6796875 = 11303475
and 11303475 : 100 : : 6796875 : x or 52·513
and 100 − 52·513 = 47·487

So that 52·513 per cent. of this cannel, plus 47·487 per cent. of this coal will make 18-candle gas, and the make of the mixture will equal

$$\begin{aligned} 52\cdot513 \times 10\cdot875 &= 5718\cdot8 \\ 47\cdot487 \times 7\cdot400 &= \underline{3514} \\ & 9232\cdot8 \text{ cubic feet.} \end{aligned}$$

Thus by logarithms

Log. 609 = 2·7846173
„ 7400 = 3·8692317

Log. 6·6538490 = 4506600

Log. 625 = 2·7958800
„ 10·875 = 4·0364293

Log. 6·8323093 = 6796800
11303400

„ 6796800 = 6·8323092
„ 100 = 2·0000000

8·8323092
„ 11303400 = 7·1120404

Log. 1·7202688 = 52·513 per cent.
„ 10·875 = 4·0364293

Log. 5·7566981 = 5718·8

„ 47·487 = 1·6765747
„ 6400 = 3·8692317

Log. 5·5458064 = 3514
9232·8 cubic feet.

And now we shall proceed to consider

C. THE WEIGHT, QUALITY AND COMPARATIVE COMMERCIAL VALUE OF THE COKE A COAL OR CANNEL PRODUCES.

In the sixteenth chapter of the third book of John Stuart Mills' 'Political Economy,' there occurs a passage where he treats of "some peculiar cases of value," and in which he illustrates the division of the subject he there discusses by instancing *gas coke* as a case in point; we cannot for obvious reasons quote *in extenso*, and shall therefore only transcribe a sentence which bears on the subject under discussion, and which will be given in italics in the following remarks.

In assigning a commercial value to the coke a coal or cannel produces, the first thing to be determined is the average value of the coke produced for the preceding year, or for a series of years, unless such abnormal ones as 1872, for instance. The whole of the money realised for coke, divided by the number of tons sold, forms a basis, together with the average quality, from which we may form a reasonable estimate of the relative commercial value of the coke produced from a coal or cannel submitted for approval and purchase. It does not often pay to *store* coke; the expense of doing so, together with rapid deterioration, and the risk of fire, make it generally more remunerative to dispose of the make as it is made. The price at which coke sells will vary according *to* "*the law of demand and supply,*" and the *law that* "*the demand for a commodity varies with its value,*"— "*and that the value adjusts itself so that the demand shall be equal to the supply.*" There are several principles which regulate the values of coke, which when known may be turned to profitable account. Gas works producing rich gas made from cannels, may sometimes, from local causes, be enabled to sell an inferior cannel coke at what might appear to be an excessive value, as compared with a neighbouring town manufacturing common gas—less cannel gas is used, and a larger proportion of coke is also required for the furnaces; the cannel may also produce a less weight of coke per ton, all of these circumstances tending to reduce the residue for sale, and on account of its greater rarity enhancing its saleable value in that district; on the other hand, if gas is manufactured from an inferior quality of coals and cannels, which also produces a low average quality of gas, we must necessarily in that case obtain a less price per ton for the coke sold, than if the same quality of gas had been made from a first-class coal, and a good cannel; the production per ton would be greater, but a less quantity of a superior quality would in all probability yield as much or more in money value.

The same effects may also be made to follow if the process of carbonizing is carried too far; to keep the quality of gas up to the standard, when too well burnt off charges discharge carbonic oxide into the holders, cannel is added, which of course deteriorates and depreciates the selling value of the coke produced. The best practice, therefore, appears to be to use a first-class coal during the depth of winter, and only as much of a good cannel producing a good quality of coke as will maintain the standard quality of gas, thus reducing the make of coke (but of good quality) to a minimum, and proportionally enhancing its value; on the other hand, during spring, summer and autumn, the *burgy*, or screenings of a first-class coal, *if used fresh*, with a good quality of cannel, will make less gas per ton, but more *coke*, *tar* and *ammoniacal liquor*. We may thus, to some extent, regulate both the price coke will command, and the quantity produced; everything, however, will be subordinated to the question: Will it pay? and what pays best? The coke should always be offered at such a price as will keep stocks *low*, and clear the yard, as the public are not slow to take advantage of excesses of supply over demand, and *withhold* demand, in the hope of reducing the value of supply, while *supply* hangs on our hand, and becomes depreciated in value, so that, instead of gaining, we become considerable losers.

We have already assumed that the average price realised for coke was equal to 6*d.* per 100 lbs., which is equal to 11*s.* 2½*d.* per ton, and we shall continue to adhere to this value in these papers when similar good qualities are required to be valued, and shall show how a table may be constructed, making this value (the year's average value) a basis for comparing inferior qualities of coke, unless an *arbitrary comparative* value, determined by inspection could be equitably substituted.

To affix an equitable comparative value to various qualities of coke by rule is doubtless difficult. Hitherto it has been unusual to estimate comparative values by the weight of water one pound of any particular quality of coke would evaporate in a vessel open to the atmosphere, but such a method seems to me to be as good as any means which could be devised for ascertaining this value.

If the best qualities of coke produced in a gasworks were found capable of evaporating say 7 lbs. of water per pound of coke, and the worst, which was disposed of for nothing, was found capable of evaporating say only 3 lbs. of water per pound of coke, then the quality which evaporated 5 lbs. would probably be found to fetch less than the half (or the mean) of the price fetched by the quality evaporating 7 lbs., and that yielding nothing (although, as has been already instanced, there are cases where high qualities of gas are manufactured from cannels, yielding a superior quality of coke *for a cannel*, where an inferior quality of cannel coke fetches a higher price than a superior quality of coal coke manufactured in a neighbouring town); but here we are comparing the values and prices yielded by various qualities produced in the *same* works, the inferior mean quality perhaps arising from the use of inferior coal or cannel, yielding, too, a small return per ton, and proportionally increasing the production of coke, and this in a higher ratio, if the illuminating power were purposely maintained at a low standard, thus producing the maximum quantity of coke from inferior qualities of coal and cannel.

In that case the price realised would be less than the mean between the highest value for best qualities, and 0—the price realised for the quality which would evaporate 3 lbs.

The descending ratios of value would correspond to the supplements of the ordinates of some curve such as a Parabola, or a Cycloid, divided equally. Thus suppose we select a Parabola, and take the value of ten equidistant ordinates:—

·0	evaporative power,	7·0 lbs.	water.
·316	„ „	6·6	„
·447	„ „	6·2	„
·547	„ „	5·8	„
·632	„ „	5·4	„
·707	„ „	5·0	„
·774	„ „	4·6	„
·836	„ „	4·2	„
·894	„ „	3·8	„
·948	„ „	3·4	„
1·000	„ „	3·0	„

Then as the value corresponded to the supplements of these ordinates, and their corresponding values would be found thus: multiply the weight of the quality to be valued by the number corresponding to the evaporative power of the coke it produces; the difference between this value and the average annual value of the average quality of coke produced will represent its corresponding value.

Thus suppose the best quality were worth 6*d.* per 100 lbs. = 11*s.* 2½*d.* per ton, corresponding to a quality evaporating 7 lbs. of water per pound of coke, and suppose another quality only evaporated 5·4 lbs. of water, what is its corresponding value? suppose the weight produced per ton equals 14·96 lbs., then 14·96 lbs. × 6*d.* = 7*s.* 6*d.*, or 7·5*s.*, which would represent its value if it were *best* coke, 7·5 × ·632 the number opposite 5·4, equals 4·7, and 7·5 − 4·7 = 2·8, equal to 2*s.* 9½*d.* per ton. We have here shown how a table may be constructed and applied, when the facts and data from which it should be framed are known. The two curves already indicated seem as suitable as any to give expression to this fall in value; percentages of ash would not of itself be sufficient, as ash may be present in coke in similar percentages, but produce dissimilar evaporative powers, consequent upon the freedom or difficulty with which the oxygen combines with the carbon, which, if the material be encased with its ash, combustion must be correspondingly imperfect.

The London Coal Exchange reckon 68 *strike* bushels as equal to a ton of coke.

D. THE WEIGHT IN POUNDS AND STRENGTH OF THE AMMONIACAL LIQUOR STATED IN TERMS OF TWADDEL OR IN OUNCES.

In both experimental and practical working, the greater part of the ammonia, together with a considerable percentage of the carbonic acid and sulphuretted hydrogen may be abstracted from the gas by passing it through a *single* continuous horizontal pipe. The central core of gas moves fastest; but having attained the maximum velocity, falls back upon the sides, so that the ammoniacal liquor which floats on the top of the tar (in the inlet the tar ought to be separated from the ammonia water, leaving the water to pass on to the condenser by means of a tar separator dip, similar to an ordinary dip, but made of tear, this would also be in the inverse ratio of 5° to 6°, and if evaporation were effected by steam, would include costs of boilers and evaporating pans. Then the fuel required would also be inversely as 5 is to 6, and the wages would be in the same proportion;—as a matter of fact 5° sold for 12*s.* in one works, while 6° in another, equidistant from the same works, sold for 20*s.*; but for the 6°, *water carriage* was resorted to; in the other, removal was effected with barrels. The difference between the two modes of carriage would probably equal 2*s.* per ton, so that 5° would probably be worth 14*s.*, where 6° would be worth 20*s.* in the particular gasworks referred to; or in the other case—where 5° was worth 12*s.*—6° would be worth 17*s.* 1*d.* The approximate money values for the following strengths in the case of road carriage, when 5° sold for 14*s.* would approximately be represented by the following prices hereafter referred to as Ammonia Water Table A.

			s.	*d.*		*s.*	
4°	Twaddel,	8 oz.	7	0	per ton or	·312	per 100 lbs.
4½°	„	9 „	9	6	„	·424	„
5°	„	10 „	12	0	„	·535	„
5½°	„	11 „	14	6	„	·647	„
6°	„	12 „	17	0	„	·759	„

In the other case where *water* carriage was used, and where 6° Twaddel was worth and sold for 20*s.*, the values would be approximately as follows:

			s.		*s.*	
4°	Twaddel,	8 or	8	per ton or	·357	per 100 lbs.
4½°	„	9 „	11	„	·491	„
5°	„	10 „	14	„	·624	„
5½°	„	11 „	17	„	·756	„
6°	„	12 „	20	„	·892	„

And now as to the manner of applying these tables. Suppose that in the latter case (B) a coal produced 160 lbs. of liquor 5½° Twaddel—then the value would be represented by 1·60 × ·756 = 1·2*s.* or 1*s.* 1½*d.*

It would introduce too nice a distinction in values to introduce the cost of eliminating the carbonic acid from the ammonia

water, and fixing its combined ammonia—which is set free by adding lime.

We shall now proceed to the consideration of the commercial values of the tar a coal or cannel produces.

E. TAR.

It is usual for a contractor to sample and analyse the tar he proposes to purchase. The highest offer accepted will in the aggregate represent the value of tar produced at that particular gasworks. Generally, this tar will be a mixture of coal and cannel tars, which *separately* have different values; the anthracine, naphthaline, and creosote, being generally more largely produced from the richer qualities of coal tars, while the naphthas form a larger proportion of the fractional distillation of cannel tars, pitch being a product of both. Perhaps the better way is to get the value of tar in a district where cannel is most largely used, but this value ought to be ascertained for the same district (if possible) as that in which a market is found for coal tars. Values might more easily be assigned from ascertaining the analysis by fractional distillation, and treatment of the residue for those products which at the time determined its value, comparing this result with the results and prices obtained for a known quality of coal and cannel tar.

Here too, such items as carriage, costs of fuel, wages, capital employed, and depreciation, all tend to affect values; depreciating the inferior, and increasing the saleable value of the superior article.

In the following estimations we shall assume its value to be 25*s*. per ton for such tar as can be made from best coal used along with 20 per cent. of good cannel, equal to 1·116 shillings, or 1*s*. 1¼*d*. per 100 lbs. For *coal* tars, 27*s*. per ton = 1·2*s*. or 1*s*. 2½*d*. per 100 lbs. and for cannel tars 22*s*. 4*d*. per ton or 1*s*. per 100 lbs.

We have now reached a position from which, by applying the preceding rules and formulæ in a manner about to be exemplified, we shall be enabled to affix an equitable value to any particular quality of coal or cannel offered for purchase.

This method consists first in selecting a fair quality of coal and cannel, each selling, or offered for acceptance at what may seem to be a fair price. This price *including the cost of delivery.* The one may be denominated the *Standard Coal*, the other the *Standard Cannel.* Obtain a *fair* practical statement of what this coal or cannel is capable of producing per ton, as for example: A coal which we shall call B. Mine C. C. Co. C—e Burgy, will on the average produce 9240 cubic feet of 17·3-candle gas, 1540 lbs. of red hot coke, 172 lbs. of tar, and 183 lbs. of ammonia water, having a strength equal to 5° Twaddel, and required 90 lbs. of lime to purify the gas it produced.*

The Standard Cannel W. Y. C. I. Co. screened cannel produces 10,333 cubic feet of 21·3-candle gas, 1350 lbs. of red hot coke, (good for a cannel) containing 15 per cent. of ash—it also produces 216 lbs. of tar, and 151 lbs. of ammonia water, having a strength equal to 5° Twaddel, and required 85 lbs. of lime to purify the gas it produced.*

First ascertain the values of the secondary products in each.

1st. The coal.	*s.*	*d.*
15·40 lbs. coke, at 6*d.* .. .. =	7	8½
1·72 „ tar, at 1·2*s.* .. .. =	1	10¾
1·83 „ ammonia water, 5° Twaddel, at ·624 =	1	1¾
So that the secondary products are worth	10	9¼

This coal sold for 13*s.* 9*d.* delivered, so that 13*s.* 9*d.* minus 10*s.* 9¼*d.* = 2*s.* 11¾*d.* would represent the value of the gas produced (9·24 × 17·3 equals 159·8) and $\frac{2s.\ 11\frac{3}{4}}{159{\cdot}8}$ equals ·223 of a penny per candle per 1000, which would in this case represent the value of the *coal* candle per 1000. This number, it may be observed, is unnecessary for computing values, but is merely introduced here to admit of its being compared with the figures similarly obtained for the standard cannel candle.

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* In this case the difference in costs for purification may be eliminated from the calculation of costs, they are so nearly alike. The gas produced from the standard coal required 90 lbs. for its purification, while the gas produced from the cannel required 85. Had the excess of the one over the other been considerable (90 × 7·5 = 6·75 and 85 × 7·5 = 6·375, so that the difference is less than ½*d.*), the excess, or the difference in costs, would first require to be deducted from that material which costs most to purify, previous to ascertaining the cost price of the gas, or the constant to be used for valuation.

And now as to the value of the secondary products produced from this cannel. This coke would not be worth more than 3*d.* per 100 lbs. when the best coke sold for 6*d.*

Coke.		s.	d.
13·50 × 3*d.*	=	3	4½
2·16 lbs. tar × 1*s.* (cannel tar)	=	2	2
1·51 lbs. ammonia water, 5° Twaddel, at ·624	=	0	11¼

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West Yorkshire [illegible]

candles per 1000, and 220 [illegible]

while it will be remembered that the value of the *coal* candle, was only equal to ·223*d.* per candle per 1000. The cost of a candle per 1000 for the coal or cannel is therefore *not* a measure of its value in another. From these two statements we find that

10,333 × 21·3 = 220·09 candles per 1000 cost 17·2¼*d.*, and that
9,240 × 17·3 = 159·85 „ „ 2·11¾*d.* Hence,

if we are to make, say 18½-candle gas from mixtures of this coal or cannel, the cost per candle per 1000 will lie somewhere intermediate between 0·223*d.* and 0·937*d.*

The next thing to be determined is the quality of the gas which we propose to manufacture. In the present instance, I shall assume it to be equal to 18½ candles.

We then apply the formulæ previously given for finding the proportion of this coal and cannel required to enable 18½-candle gas to be manufactured from the mixture.

$$\begin{array}{lcl} 18{\cdot}5 - 21{\cdot}3 & \diagdown\!\!\!\diagup & 1{\cdot}2 \text{ of cannel.} \\ 18{\cdot}5 - 17{\cdot}3 & \diagup\!\!\!\diagdown & 2{\cdot}8 \text{ of coal.} \end{array}$$

Therefore 18½-candle gas can be manufactured from a mixture $\frac{12}{10,333}$ of cannel, plus $\frac{28}{9,240}$ of the coal.

Then 110·80 + 289·324 : 100 :: 110·880 : 27·7, consequently 27·7 per cent of this cannel, plus 72·3 per cent. of this coal, will make 18½-candle gas, and the make of the mixture per ton will equal,

27·7 per cent. of 10,333 = 2862
72·3 „ 9,240 = 6680
9542 cubic feet.

And now as to the cost.

	s.	d.		s.	d.
27·7 per cent.	17	2¼	= 57·13 =	4	9
72·3 „	2	11¾	= 25·84 =	2	1¾
			82·97 =	6	10¾

We now find the cost of a candle per 1000 for 18½-candle gas, thus, 18·5 × 9·542 = 171·756 candles, and $\frac{82{\cdot}97}{171{\cdot}756} = 0{\cdot}48d.$, or nearly ½*d.* per candle per 1000—which is a measure of value for gas of this quality (18½ candles), or we may find the values of three constants which may be so applied as to be used in substitution of proportional methods of obtaining comparative values; for instance, in this case these constants will be,

d.

$\frac{35{\cdot}75}{9{\cdot}240} = 3{\cdot}87$ * for 1000 cubic feet of 17·3-candle gas.
$\frac{82{\cdot}97}{9{\cdot}542} = 8{\cdot}69$ „ „ 18·5 „
$\frac{206{\cdot}5}{10{\cdot}333} = 19{\cdot}98$ „ „ 21·3 „

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* When the price of the standard coal selected is such that the price delivered is equal to the sum of the values of the secondary products—tar,

and the following example will show how the particulars, prices, and constants here given are to be applied to the commercial valuation of other qualities of coal and cannels.

EXAMPLE I.

A Nottingham cannel, producing 7860 cubic feet of 19·1-candle gas. This cannel also produced 1325 lbs. of coke, which was found to contain 54 per cent. of ash, and was therefore worthless, ($\frac{3}{4}$*d.* or 0·75*d.* per 100 lbs. having to be paid to have it carted away). The tar weighed 185 lbs., and the ammonia water weighed 230 lbs., which we shall *assume* had a strength 4° Twaddel.

First, find how much of this cannel would be required to be used along with the standard coal to produce 18½-candle gas.

$$\begin{array}{ccc} 18 \cdot 5 - 19 \cdot 1 & \diagdown\!\!\!\diagup & 1 \cdot 2 \\ 18 \cdot 5 - 17 \cdot 3 & \diagup\!\!\!\diagdown & 0 \cdot 6 \end{array}$$

therefore $\frac{12}{7860}$ of this cannel, + $\frac{6}{9240}$ of the standard coal, will manufacture 18½-candle gas. The numerators, 110·88 : of cannel + 47·160 of coal : 100 : : 110·88 : 70·15 per cent. of cannel. Therefore 70·15 per cent. of this cannel, plus 29·85 per cent. of the standard coal, will be required to make 18½-candle gas from the mixture,

70·15 per cent. of 7860 = 5513
29·85 „ 9240 = 2758

So the mixture will produce 8271 cubic feet of

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coke, and ammonia water,—then this standard coal constant will equal 0·0. Or again, should the price delivered be such that the sum of the values of the tar, coke, and ammonia liquor (together with the carbonizing and other expenses—should the make of the standard coal exceed that of the standard cannel) *exceeds* that of the cost of the standard coal delivered, then this standard coal constant will resolve itself into a *minus* value (the cost price of the gas produced from it being less than 0), and in estimating for the value of the constant representing the intermediate quality of gas to be made from the mixture, it will be the *algebraic sum* of the two which will in this case be used for obtaining this value. The coal constant being used as a *negative* (−) value, which will in that case be substituted for this positive (+) value in this and other applications of these formulæ.

18·5-candle gas. But 9,542 cubic feet of 18·5-candle gas was found to be worth 82·97*d.*, consequently 8,271 cubic feet × the constant 8·69 * (the value in the material of 1000 cubic feet of 18·5-candle gas) = 71·874*d.* or 5*s.* 11¾*d.*

But 2758 cubic feet of the standard coal gas was used to produce this 8271 cubic feet of 18·5-candle gas, which, multiplied by the constant, 3·87, equals 10·673*d.* and 71·874*d.* minus 10·673*d.* = 51·201 or 4*s.* 3¼*d.* will therefore represent the value of 5513 cubic feet of 19·1-candle gas produced from this cannel, which was found to be equal to 70·15 per cent. of its production, 72·98*d.* or 6*s.* 1*d.* will consequently represent the comparative value of the gas this cannel produced, and $\frac{72\cdot98d.}{7860} = 9\cdot38d.$ will represent the value of 19·1-candle gas per 1000 in this cannel.

With these results we may now proceed to sum up the values as compared with the value of the standard cannel.

	s.	*d.*
The gas is worth	6	1
1·85 lbs. tar at 1*s.* per 100 lbs.	1	10¼
Ammonia water 2·30 lbs. 4° T. at ·357 = ·821*s.* ..	0	10
So that these products are worth	8	9¼

But the coke had to be carted away, at a cost and loss of ¾*d.*, 0·75*d.* per 100 lbs. on 13·25 lbs. = 9¾*d.*, and the difference between carbonizing and other cost for a coal yielding 10,333, and one yielding 7860 = 8*s.* 6*d.* − 6*s.* 5*d.* = 2*s.* 1*d.* and 8*s.* 9¼*d.*

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* This 8¾*d.* per 1000 for 18·5-candle gas must not be confounded with the selling or cost price of gas. To this must be added (for a company) such charges as wages for carbonizing, charges for wages and material used for purifying, a charge to cover leakage, dividend rates, such as 6*d.*, 1*s.*, 1*s.* 6*d.*, 2*s.*, 3*s.*, or some other charge which is found sufficient to pay the stipulated dividend for use of capital employed. This additional charge also includes, charges for wear and tear, cost of renewals and depreciation (unless the works are continually kept in such condition as to be considered equal to new), and it may be added, all other charges which are a legitimate item in cost to consumer. In corporations—capital is required to be bought up out of revenue, and charges are sometimes made on a gas department which amount to indirect taxation, and ought to form no legitimate charge upon gas manufacture—such as gas rentals paying for rates—or, in one case to pay for interest, 3½*d.* per 1000, for moneys lent to another department, that department having exceeded their borrowing powers, although the gas department had not.

minus 2*s.* 10¾*d.*, that is (2*s.* 1*d.* + 9¾*d.*) = 5*s.* 10½*d.* But this Nottingham cannel was selling for 16*s.* delivered, when the standard cannel was selling for 24*s.* 6*d.*, showing a loss from its use equal to 10*s.* 1½*d.* per ton used.

EXAMPLE II.

A coal producing 9440 cubic feet of 15·9-candle gas, 245 lbs. of tar, 190 lbs. of ammonia water, having a strength equal to 5° Twaddel, and also producing 1460 lbs. of coke containing 5 per cent. of ash. What was its value as compared with that of the standard coal?

First find the quantities required to manufacture 18½-candle gas when used along with the standard cannel.

$$\begin{array}{lcl} 18{\cdot}5 - 15{\cdot}9 & \searrow\!\!\!\nearrow & 2{\cdot}8 \\ 18{\cdot}5 - 21{\cdot}3 & \nearrow\!\!\!\searrow & 2{\cdot}6 \end{array}$$

therefore $\frac{28}{9440}$ of coal, plus $\frac{26}{10,333}$ of cannel will make 18½-candle gas.

The numerators, 289,324 of coal + 245,440 of cannel : 100 : : 289,324 : 54·1 per cent. of this coal. Therefore 54·1 per cent. of this coal + 45·9 per cent. of this cannel will manufacture 18½-candle gas, and

54·1 per cent. of 9440 = 5107
45·9 „ 10,333 = 4742

So the mixture will produce 9849 cubic feet of 18½-candle gas, and 9,849 × the constant 8·67*d.* for 18½-candle gas = 85·19*d.* or 7*s.* 1½*d.* But this mixture contained 4,742 cubic feet of the standard cannel, worth 19·98*d.* per 1000 cubic feet of 21·3-candle gas, and 4,742 × 19·98 = 94·76*d.*, or 7*s.* 10¾*d.*; consequently the 5,107 cubic feet would be worth 94·76 − 85·39 = 9·37 *less than nothing*, a negative value; but this 9·37*d.* represents only 54·1 per cent. of this loss; on 100 per cent. the loss equals 17·32*d.* or 1*s.* 5½*d.*,—the 15·3-candle gas per 1000 equals 2*s.* 2*d.* in this case, and would therefore be a negative value, consequent upon the large percentage of cannel requisite to maintain the illuminating power, to prevent which loss in such cases *illuminating power is not unfrequently sacrificed.*

And now as to the sum of the values of the various products of this coal.

		s.	*d.*
14·60 lbs. of coke at 6*d.*	=	7	3½
2·45 lbs. of tar at 1*s.* 2*d.*	=	2	11¼
1·90 lbs. of ammonia water of 5° Twaddel × ·624*s.*	=	1	2½
Difference carbonizing expenses in favour of this coal, 9440 − 9240	=	0	2
		11	7¼
Less loss for gas produced		1	5½
So that this coal is worth		10	1¾

when the standard coal was selling for 13*s.* 9*d.*, but this coal sold for 14*s.* delivered, showing a loss of 3*s.* 10¼*d.* per ton.

It will be seen how important it is to have coal *correctly* tested from fair average samples of the material offered, as thereby full advantage may be taken of the low market value of any particular quality which promises the most profitable returns.

EXAMPLE III.

The following Example is one of those which led us to make the present inquiry.

A coal produces 7400 cubic feet of 11·9-candle gas, it also produces 1650 lbs. of coke containing 12 per cent. of ash. The tar it produced weighed 115 lbs., and the ammonia water, whose strength we shall estimate at 4½° Twaddel, equalled 143 lbs.

Find, as before, the percentages requisite to produce 18½-candle gas along with the standard cannel.

$$\begin{array}{l} 18\cdot5 - 11\cdot9 \\ 18\cdot5 - 21\cdot3 \end{array} \times \begin{array}{l} 2\cdot8 \\ 6\cdot6 \end{array}$$

Therefore $\frac{66}{10,333}$ of this cannel, plus $\frac{28}{7400}$ of this coal will manufacture 18½-candle gas.

Then 488400 of cannel + 289324 of coal : 100 : : 488400 : 62·97 per cent. of cannel, so that 62·97 per cent. of the standard cannel, plus 37·21 per cent. of this coal, will be required to manufacture 18½-candle gas, and the return per ton will equal

62·79 per cent. of 10,333 = 6488
37·21 „ 7,400 = 2753

This mixture will therefore produce . 9241 cubic feet of 18½-candle gas, 9,241 × the constant 8·69 = 80·3*d.* equal 6*s.* 8¼*d.*; but 6,488 cubic feet of this mixture was produced from the standard cannel, the constant for this 21·3 cannel gas being 19·98*d.* per 1000, and 19·98*d.* × 6,488 = 129·63*d.* = 10*s.* 9¾*d.*, from which it appears that this 6,488 cubic feet cost more than the whole 9,241 cubic feet was worth. 129·63 − 8·03 = 49·33 or 4*s.* 1¼*d.* would therefore show the loss which would be sustained by the use of 2,753 cubic feet of this 11·9-candle gas; the loss on the production of a ton, 7400 cubic feet, would therefore be 11*s.* 6*d.* 2753 : 7400 : : 49·33 : 13·25 or 11*s.* 6*d.*

The secondary products would be worth—

	s.	*d.*
Coke 1650 lbs., which, on account of the large production and inferior quality, would not be worth more than 4½ per 100 lbs., when the best produced from coals yielding 9500 cubic feet per ton sold for 6*d.* per 100 lbs., 16·50 × 4·5 =	6	2½
1·15 lbs. tar at 1·2*d* = 1·38*s.*	1	4½
1·43 lbs. a. water of 4½° T. at 491*s.* = 7*s.*	0	8½
So that these secondary products are worth	8	3½

The difference between the carbonizing expenses, etc., etc., etc., between the standard coal producing 9,240 cubic, and the one producing 7400 = as per table, equals,

	s.	*d.*
9*s.* minus 7*s.* 2*d.*..	1	10
The loss from gas	11	6
Together equal to	13	4

and 13*s.* 4*d.* − 8*s.* 3¼*d.* = 5*s.* 0¾*d.*, would show how much this coal was worth ***less than nothing*** (a negative value) for ***gas manufacturing*** purposes, when the standard coal could be had fur 13*s.* 9*d.*, and the standard cannel for 24*s.* 6*d.* delivered; but this coal sold for 14*s.* delivered, and 14*s.* + 5*s.* 0¾*d.* = 19*s.* 0¾*d.*, would therefore represent the loss on each ton used, not far short of £3000 on a 3000 ton contract; further comment on this "***bargain***" is superfluous.

EXAMPLE IV.

A sample of a seam composed of a mixture of coal and cannel produced 9660 cubic feet of 20·2-candle gas; it also produced 1210 lbs. of red-hot coke, which contained 8 per cent. of ash, 209 lbs. of tar, 240 lbs. of ammonia water, having a strength equal to 5° Twaddel; what was it worth as compared with the standard cannel producing 10,333 cubic feet of 21·3-candle gas?

First find the percentage of it required to be used along with the standard coal to produce 18½-candle gas.

$$\begin{array}{l} 18\cdot5 - 20\cdot2 \\ 18\cdot5 - 17\cdot3 \end{array} \times \begin{array}{l} 1\cdot2 \\ 1\cdot7 \end{array}$$

therefore $\frac{12}{9660}$ of this coal and cannel mixture + $\frac{17}{9240}$ of the standard coal would together make 18½-candle gas, and 11088 of cannel + 16422 of coal : 100 : 11088 : 40·3 per cent. of the coal and cannel mixture. Therefore 40·3 per cent. of this coal and cannel mixture + 59·7 per cent. of the standard coal will produce 18½-candle gas.

40·3 per cent. of 9660 = 3892·9
59·7 „ 9240 = 5516·2

So this mixture will produce 9409·0 cubic feet of 18-candle gas. 9,406 × constant 8·69 = 81·76*d.* = 6*s.* 11¾*d.*; but 59·7 per cent. of the production of a ton of the standard coal, producing 9240 cubic feet, equal to 5,516 cubic feet, were used in the mixture, and 5,516 × constant 3·87 = 21·34 = 1*s.* 9¼*d.*; 81·76 − 21·34 = 60·42 or 5*s.* 0½*d.*, will therefore represent the value of the 40·3 per cent. of the gas produced from the coal and cannel mixture, or the 3892 cubic feet: the 9660 cubic feet would therefore be worth,

3892 : 9660 :: 60·42*d.* : 149·1 or 12*s.* 5*d.*

	s.	*d.*
The gas produced was therefore worth	12	5
Difference between 9660 and 9240 cubic feet for carbonizing, and other expenses in favour of this coal .. .. =	0	3
1·50 lbs. tar at 1·116 = 1·674 .. .. =	1	8
190 lbs. ammonia water of 5° Twaddel at ·6244*s.* = 11·85*d.*	0	11¾
12·10 lbs. coke at, say 5*d.* when the best sold at 6*d.* *for the year's* average	5	0½
So that this mixture would be worth ..	20	4¼

when the standard coal sold for 13*s.* 9*d.*, and the standard cannel for 24*s.* 6*d.* delivered.

Example V.

The late Mr. Evans gives a testing of a particular Scotch cannel producing 13,500 cubic feet of 27·1 candle gas (this would of course be tested with a "bat's-wing"), and will therefore probably be less than its *equational illuminating power* value, or its value in a mixture of coal gas to produce, say 17-candle gas, suppose we call it 28·6-candle gas; it is also stated to produce 1129 lbs. of coke containing 18 per cent. of ash. The weights of tar and ammonia water are not stated, we shall therefore assume them to be of similar weight to those assigned to the standard cannel.

$$\begin{array}{l} 18\cdot5 - 28\cdot6 \\ 18\cdot5 - 17\cdot3 \end{array} \times \begin{array}{l} 1\cdot2 \\ 10\cdot1 \end{array}$$

Therefore $\frac{12}{13{,}500}$ of this cannel + $\frac{101}{9240}$ of this standard coal will together produce 18½-candle gas. The numerators 110880 of cannel + 1363500 of coal : 100 : 110880 : 7·5. Therefore 7·5 per cent. of this cannel + 92·5 per cent. of the standard coal will together produce 18½-candle gas.

7·5 per cent. of 13,500 = 1012·5
92·5 „ „ 9,240 = 8547

So the mixture will produce 9559·5 cubic feet of 18½-candle gas, 9559 × constant 8·69 = 83·06*d.* = 6*s.* 11*d.*; the 8,547 cubic feet produced from the coal would be worth 8,547 × constant 3·87 = 33·07*d.* = 2*s.* 9*d.*, and 83·06 − 33·07 = 50·0*d.*, or 4*s.* 2*d.*, will therefore represent the value of the 7·5 per cent., or the 1012 cubic feet of the gas produced from this cannel; for 13,500 cubic feet, the value would therefore be 7·5 : 100 :: 50*d.* : 666·66, or 55*s.* 6½*d.*

	£	*s.*	*d.*
So that the gas produced was worth	2	15	6½
Tar as per standard cannel	0	1	10¾
Ammonia water as per do.	0	1	1¾
Tabular difference for carbonizing, &c., between cannel producing 13,500 and 10,333 = 6*s.* 5*d.* − 4*s.* 11*d.* .. .. =	0	1	6
Coke 11·29 lbs. worth, say 2½*d.* per 100 lbs. when the best coke averaged 6*d.*	0	2	2¼
So that this cannel would be worth	3	2	3¼
(Laboratory test) less 20 per cent.		12	3¼
	£2	10	0

when the standard cannel was selling at 24*s.* 6*d.*, and the standard coal for 13*s.* 9*d.*

EXAMPLE VI.

A coal and cannel mixture produces 9720 cubic feet of 17·4-candle gas − 1140 lbs. of coke containing 12 per cent. of ash − 150 lbs. of tar − 190 lbs. of ammonia water having a strength equal to 5° Twaddel.

$$\begin{array}{lcl} 18{\cdot}5 - 17{\cdot}4 & \searrow\!\nearrow & 2{\cdot}8 \\ 18{\cdot}5 - 21{\cdot}3 & \nearrow\!\searrow & 1{\cdot}1 \end{array}$$

Therefore $\frac{28}{9720}$ of this coal and cannel mixture, plus $\frac{11}{10,333}$ of the standard cannel, will produce 18½-candle gas – the numerators 289·324 of this coal and cannel mixture + 106·920 of cannel : 100 : 289·324 : 73 per cent. therefore 73 per cent. of this coal and cannel mixture—plus 27 per cent. of the standard cannel will make 18½-candle gas.

73 per cent. of 9,720 = 7095
27 „ „ 10,333 = 2790

So the mixture will produce 9885 cubic feet of 18½-candle gas, 9,559 × constant 8·69=85·9*d.* or 7*s.* 2*d.*; but 2,790 cubic feet were produced from the standard cannel, which, multiplied by its constant 19·98 = 55·74 = 4*s.* 7¾*d.* 85·9 – 55·74 = 30·16 will therefore represent the value of 73 per cent., or 7095 cubic feet of this coal and cannel mixture; so that the 9720 cubic feet this material produced per ton would be worth $\frac{3016}{73}$ = 41·31*d.* or 3*s.* 5½*d.*

	s.	*d.*
The gas this mixture produced was worth ..	3	5½
Difference, carbonizing, &c., expenses, between coal yielding 9240 and 9720 .. .. .. =	0	5
150 lbs. tar at 1·116 = 1·674	1	8
190 lbs. ammonia water of 5½° Twaddel at ·756 = 1·436	1	5¼
Coke 11·40 lbs. at, say, 4½*d.*	4	3¼
So this coal was worth	11	3

Yet this coal sold for 16*s.* 6*d.* delivered, when the standard coal sold for 13*s.* 9*d.* delivered, all showing that the standard coal was exceptionally cheap.

In some districts of Lancashire, companies possess *exceptional* advantage of obtaining the *burgy*, or the small coal separated or screened from the *round* coal, which if used *direct* from the mine, is found to produce *good* results, and at a low cost, all the secondary products being also very valuable; this is more particularly the case with the Black mine coals found near Ashton and Oldham, the use of this material has doubtless given rise to the *four hour* work practised in that district; the coal being fine, it is necessary to charge in thinner layers, and if the charging is effected regularly, there can be no doubt of the benefits arising out of the practice, as both quality and quantity are thereby increased.

I shall now conclude this first series of examples by estimating the comparative value of an Australian shale producing 16,500 cubic feet of 47-candle gas. The *equational illuminating power* would doubtless exceed this value, but we shall adhere to this statement. I cannot state its production of oil, but shall substitute the quantity produced from Chatterly shale (English) equal to 25·28 gallons, or say 160 lbs. of oil. Coke valueless.

I may here exemplify how logarithms may be applied instead of the system hitherto adopted.

In one case where 100 is used for percentage calculations 2 will be the characteristic, and seven noughts the mantissa. I shall compare both methods as I proceed.

First, then, find the fractional proportions of shale and standard coal required to make 18½-candle gas.

$$\begin{array}{c} 18\cdot5 - 17\cdot3 \\ 18\cdot5 - 47\cdot0 \end{array} \times \begin{array}{c} 28\cdot5 \\ 1\cdot2 \end{array}$$

Therefore $\frac{28\cdot5}{9240}$ of the standard coal + $\frac{1\cdot2}{16\cdot500}$ of the shale will make 18½-candle gas. Find the numerators by the ordinary arithmetical method.

$\frac{28\cdot5}{9240} + \frac{1\cdot2}{16\cdot500}$ = 470·25 of coal, plus 11·0880 of shale, or by logarithms.

$$\begin{array}{lll} \text{Log.}\ 28\cdot5 & = & 1\cdot4548449 \\ \quad,,\ \ 16\cdot500 & = & \underline{1\cdot2174839} \\ \quad,,\ \ 470\cdot25 & = & 2\cdot6723288 \end{array}$$

So that 470·25 equals the coal numerator. The shale numerator will be found thus:

Log. 1·2 = 0·0791812
„ 9·240 = 0·9656720

„ 11·088 = 1·0448532

Therefore 11·078 = the numerator for the shale, and 470·25 +11·088 : 100 : : 470·25 : 97·5, or by logarithms—

Log. 470·25 = 2·6723288
Log. 100·00 = 2·0000000

4·6723288
470·25
11·088

Log. 481·338 = 2·6824429

97·698 = 1·9898859

Therefore 97·698 per cent. of the 17·3-candle gas produced from a ton of the standard coal producing 9,240 cubic feet, together with 2·322 per cent. of this Australian shale producing 16,500 cubic feet of 47-candle gas, will together make 18½-candle gas, and the mixture will produce 9,410 cubic feet per ton of the mixture.

97·698 per cent. of 9,240 = 9027·3
2·322 „ 16,500 = 383·13

9410·43

which may also be computed by logarithms thus:

Log. 97·698 = 1·9898859
Log. 9240 = 3·9656720

Log. 902·730 = 5·9555579

or again,

Log. 2·322 = 0·3658622
Log. 16·500 = 4·2174839

Log. 383·39 = 4·5836461

So that by logarithms, the return per ton of the mixture will equal

9027·3
383·39

9410·69 cubic feet, which, multiplied by the constant 8·69 for 18½-candle gas, will equal 81·77*d.*, or 6*s.* 11¾*d.*, but 9027 feet in this mixture were produced from the coal which, multiplied by the standard coal constant 3·87*d.* = 34·9*d.*, or 2*s.* 11*d.*; 81·77 − 34·9 =46·87*d.* will therefore represent the value of 383,39 cubic feet of this shale gas; 16,500 cubic feet would therefore be worth 2171*d.*,

		£	s.	d.	
or		£8	0	11	per ton.
Difference, carbonizing, &c., between 16,500 and 10,333 = 6·5*d.* − 4*s.* ..	=		2	1	
Shale oil, as per estimate, 160 lbs. at 1*s.*	=		1	7	

So that this shale would be worth £8 4 7 less the cost of removing its ash, or say £8 4*s.* The laboratory results exceed the *best* practical ones by 20 per cent., £8 4*s.* less 20 per cent. or £1 15*s.*, leaving £6 9*s.* to represent its comparative value *when the standard coal* sold for 13*s.* 9*d.*, *and the standard cannel* for 24*s.* 6*d.*

With such a shale as this, and a quality of coal like the *New Zealand Westport* coal co.'s, obtained from a seam 53 feet 3 in. thick, 2,000 feet above the sea, and perhaps superior in quality to any found in England, the Australasian gas companies *ought* now to be in a position to make a first-class quality of gas economically.

And now I shall conclude this series of valuations after this system by giving a few more examples.

The prices for the standard coal and cannel, a different coal from the last, being taken at their selling price delivered, *after* coal and cannel had fallen to something like their normal values.

The analysis of the standard cannel selected for the following estimates, as well as for the preceding ones, I need not repeat.

The coal we shall this time select for the standard of comparison is one producing 10,060 cubic feet of 17·3-candle gas, 1500 lbs. of coke, 170 lbs. of tar, and 180 lbs. of ammonia water, having a strength equal to 5° Twaddel, and requiring 80 lbs. of lime to purify the gas it produced.

In this case the standard cannel was selling for 25*s.* delivered, when the coal selected for a standard sold at 14*s.* 6*d.* delivered, on the works.

First, in each case, find the value of the secondary products. Cannel.

	s.	*d.*
1350 lbs. coke, at 4½*d.* per 100 lbs.	5	0¾
216 lbs. tar, at 1*s.*	2	2
150 lbs. ammonia water, at ·535*s.* (5° T.)	0	9½
So these products are worth	8	0¼
Difference in carbonizing, &c., costs for cannel producing 10,333 and coal producing 10,060	*0	2¼
Therefore the 10,333 cubic feet of 21·3-candle gas cost 25*s.* minus	7	10

or 17*s.* 2*d.* or 206*d.* $\frac{206d.}{10,333} = 19\cdot09d.$ per 1000, for this 21·3-candle gas (which is the constant) to be used for estimating values of percentages of standard cannel.

And now as to the coal.

	s.	*d.*
1500 lbs. coke, at 6*d.*	7	6
170 lbs. tar, at 1*s.* 2*d.*	2	0
180 lbs. ammonia water, 6° Twaddel, at 759	1	4
Secondary products coal worth	10	10

14·6*d* − 10*s.* 10*d.* = 3*s.* 8*d.* or 44*d.*, which represents *cost price* of gas in the coal $\frac{44}{10,060} = 4\cdot374d.$ per 1000, which is the constant to be used for valuing the quantities of gas for standard coal.

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* This 2¼ is here *deducted*. It was paid to the colliery proprietor in consideration of the superior *productiveness* of the quantity of gas produced, and not for the gas illuminating power.

And now in this case suppose we purpose to manufacture 19-candle gas; find the percentages of this coal and cannel requisite to manufacture that quality of gas.

$$\begin{array}{lcl} 19 - 17\cdot3 & \searrow\!\!\!\!\nearrow & 2\cdot3 \\ 19 - 21\cdot3 & \nearrow\!\!\!\!\searrow & 1\cdot7 \end{array}$$

Therefore $\frac{2\cdot3}{10,060}$ of coal gas + $\frac{17}{10,333}$ of this cannel gas will make 19-candle gas.

23 × 10,333 = 237659 will equal the numerator for the coal, and 17 × 10,060 = 171020, the numerator for the cannel.

And now as to percentages.

237659 of coal + 171020 of cannel, or 408679 of both : 237659 of coal : 100 : 58·15 per cent. of coal; 100 − 58·15 = 41·85 will therefore equal the percentage of cannel required. The make per ton of the mixture will equal

$$\begin{array}{r} 58\cdot15 \times 10,060 = 5849\cdot89 \\ 41\cdot85 \times 10,333 = \underline{4324\cdot46} \end{array}$$

Therefore the mixture will make 10,174·35 cubic feet of 19-candle gas.

5·849 coal × coal constant 4·374 = 25·583*d.* and 4·324 × 19 : 09 = 82·545*d.* together = 108·128*d.*, which is the value of the 10,174 cubic feet of 19-candle gas $\frac{108\cdot128}{10174} = 10\cdot62$*d.*, which represents the cost price in the two materials of 1000 cubic feet of 19-candle gas. We have now three constants from which we can proceed to ascertain the values of other coals and cannels.

These constants are—

4·374*d.* per 1000 for 17·3-candle gas.
10·62*d.* „ 19·0 „
19·09*d.* „ 21·3 „

EXAMPLE VII.

A coal, a mixture of coal and cannel produces 9720 cubic feet of 17·4-candle gas, 1350 lbs. coke, containing 12 per cent.

of ash, 216 lbs. tar, and 150 lbs. ammonia water, having a strength equal to 5° Twaddel.

First find the percentages required to be used along with the standard cannel to produce 19-candle gas.

$$\begin{array}{ccc} 19 - 17\cdot4 & \searrow\!\nearrow & 2\cdot3 \\ 19 - 21\cdot3 & \nearrow\!\searrow & 1\cdot6 \end{array}$$

Therefore $\frac{23}{9720}$ of this coal + $\frac{16}{10333}$ of this standard cannel will together make 19-candle gas, $\frac{23}{9720} + \frac{16}{10\cdot333}$ the numerators of these fractions will equal 237659 for the coal, and
158520 for the cannel

396179 : 100 : 237659 : 59·9 per cent. of coal—so that 40·1 will equal the percentages of cannel required.

59·9 per cent. of 9720 = 5822·28
40·1 „ 10·333 = 4143·53

So that the mixture will make 9965· cubic feet.

9,965 × 10·62 = 105·80*d.* or 8*s.* 9¾*d.*, but 4·143 cubic feet of standard cannel gas were used in the mixture, 4·143 × 19·09*d.* = 79*d.*, or 6*s.* 9*d.*, so that this 5·822 cubic feet of coal gas is worth 105·8 − 79 = 26·8*d.* $\frac{9720 \times 26\cdot8}{5822}$ = 44·7*d.* = 3*s.* 8¾*d.*, which represents the value of the gas produced from this coal.

	s.	*d.*
The gas is worth	3	8¾
13·50 lbs. coke, at 4*d.* = 54*d.*	4	6
216 lbs. tar, at 1·2	2	2
150 lbs. ammonia water 5° Twaddel, at 535*d.* ..	0	9½
	11	2¼
Difference carbonizing, &c., expenses		2¼
So that this coal is worth	11	0

when the standard coal (a Wigan), sells for 14*s.* 6*d.* But this coal sold for 16*s*. 6*d*., showing it was over-priced by 5*s*. 6*d*. per ton, as compared with the Wigan coal.

We may now proceed to find the comparative value of a coal yielding 9240 cubic feet of 17·3-candle gas, 1550 lbs. of coke, 176 lbs. of tar, and 183 lbs. of ammonia water having a strength equal to 5½° Twaddel.

First, find the percentages required, and the make per ton when used along with the standard cannel.

$$\begin{array}{lcl} 19 - 17{\cdot}3 & \times & 2{\cdot}3 \\ 19 - 21{\cdot}3 & & 1{\cdot}7 \end{array}$$

$\frac{23}{9240}$ of coal + $\frac{17}{10{\cdot}333}$ of cannel will make 19-candle gas.

237659 = numerator for coal, and
157080 = „ cannel

394739 : 100 : : 237659 : 60·2 per cent. of coal, which leaves a balance of 39·8 per cent. for standard cannel.

$$9240 \times 60{\cdot}2 = 5562{\cdot}4$$
$$10{\cdot}333 \times 39{\cdot}8 = 4112{\cdot}5$$

The mixture will produce .. 9675
and 9·675 × 10·62 = 102·748*d*. = 8*s*. 6¾*d*.

But 4·112 × 19·09 = 78·49*d*.—and the differences equals 24·25*d*. $\frac{9{\cdot}240 \times 24{\cdot}25}{5{\cdot}562} = 40{\cdot}27$*d*. or 3*s*. 4¼*d*.

	s.	*d*.
The gas is worth	3	4¼
1550 lbs. coke, at 6*d*.	7	9
176 lbs. tar, at 1·2	2	1
183 lbs. ammonia water 6° Twaddel at ·759 ..	1	4
So these products are worth	14	6
Tabular difference between carbonizing expenses, 10·060 and 9240 = 72*d*. − 68*d*. ..		6
So this coal is worth	14	0

delivered, when the standard coal was selling for 14*s*. 6*d*., and the standard cannel at 25*s*. delivered, it sold for 13*s*. 6*d*. There was therefore an advantage of 6*d.* per ton at that time in its favour.

Boghead produces 13,887 cubic feet of 44·16-candle gas, the coke is worthless, it contains 71·5 per cent. of ash, tar not stated, we shall assume it to produce 160 lbs.

First, find the proportions required to make 19-candle gas with the standard coal.

$$\begin{array}{lcl} 19\cdot \quad - 17\cdot 3 & \diagdown\!\!\diagup & 25\cdot 16 \\ 44\cdot 16 - 19 & \diagup\!\!\diagdown & 1\cdot 70 \end{array}$$

so that $\frac{2516}{10\cdot 060}$ of coal + $\frac{170}{13\cdot 887}$ of cannel will make 19-candle gas. (This is probably a *laboratory* test, as was the Australian shale.) These high-class cannels should of course be worked with the soundest clay, or iron retorts, at a high heat, with four-hour charges, but these laboratory tests are *quite* unsuited for staking the commercial success of gas undertakings upon results thus obtained; we merely give these values, having no practical ones to substitute for them to illustrate the subject under discussion.

$$\begin{array}{ll} \text{Log. } 25\cdot 16 & = 1\cdot 3830969 \\ \text{Log. } 13\cdot 887 & = 4\cdot 1426084 \\ \cline{2-2} \text{Log. } 3\cdot 35510 & \ 5\cdot 5257053 \\ \text{Log. } 1\cdot 70 & = 0\cdot 2304489 \\ \text{Log. } 10\cdot 060 & = 4\cdot 00259768 \\ \cline{2-2} \text{Log. } 1\cdot 7102 & = 4\cdot 23304651 \end{array}$$

$$\begin{array}{r} 335510 \\ 17102 \\ \hline 352612 \end{array}$$

352612 : 100 : : 335510 : x

$$\begin{array}{rl} \text{Log. } 100 & = 2\cdot 0000000 \\ \text{Log. } 335510 & = 5\cdot 5257053 \\ \cline{2-2} \text{Log. } 2612 & = 7\cdot 5257053 \\ \text{Log. } 353620 & = 5\cdot 5472946 \\ \cline{2-2} \text{Log. } 95\cdot 151 & = 1\cdot 9784107 \end{array}$$

Therefore 95·151 per cent. of the coal and 4·849 of this shale will make 19-candle gas.

$$\begin{array}{lcrl} 95\cdot151 \text{ per cent. of} & 10\cdot060 = & 9572 \\ 4\cdot849 \quad ,, & 13\cdot887 = & 673 \\ \hline \end{array}$$

The mixture will produce 10·245 cubic feet of 19-candle gas.

10·245 × const. 10·62 = 108·80, or 9s. 0¾d., but 9572 × const. 4·374 = 41·86d.

So the 673 are worth 66·94d., and $\frac{13\cdot887 \times 66\cdot94}{673} = 1381\cdot3d.$, or £5 10s. 3d. per ton, a value which doubtless could not be abstracted in practice, and which shows the absurdity of affixing a comparative value to *laboratory tests* unless reduced by 20 per cent., and also the necessity for carefully affixing the constant value.

	£	s.	d.
Gas	5	10	3
Tar, say	0	2	0
Carbonizing, &c., difference between 13,887 and 10,333	0	2	6
	5	14	9
Less 9*d.* for removing ash	0	0	9
So this cannel would be worth	£5	14	0

if, in practice, it could be depended upon to manufacture the quality and quantity stated. £5 14s., less 20 per cent. for laboratory testing, = £4 11*s.* 3*d.* per ton.

A certain Wigan cannel, reported by Mr. Paterson of Warrington, to produce 11,580 cubic feet of 22·73-candle gas, 1400 lbs. of coke, containing 7·32 per cent. of ash, tar not given, we shall therefore estimate its value as similar to that of the standard cannel. What is its value as compared with the standard cannel?

$$\begin{array}{rcl} 19 - 17\cdot3 & \diagdown\!\!\!\diagup & 3\cdot73 \\ 22\cdot73 - 19 & \diagup\!\!\!\diagdown & 1\cdot7 \end{array}$$

Therefore $\frac{3\cdot73}{10\cdot060}$ of the standard coal, + $\frac{1\cdot7}{11\cdot580}$ of this Wigan cannel, will make 19-candle gas.

Log. 3·73 = 0·5717088
Log. 11·580 = 4·0637086

Log. 43193 = 4·6354174

Log. 1·7 = 0·2304489
Log. 10·060 = 4·00259798

Log. 1·7110 = 4·23304688
and 43193 of coal + 17110 of cannel : 100 : : 43193 : *x*
Log. 43193 = 4·6354174
Log. 100 = 2·0000000

6·6354174

43193
17110

Log. 60303 = 4·7803389

Log. 71·627 = 1·8550785

100
71·627

28·373

therefore 71·627 per cent. of the standard coal, plus 28·373 per cent. of this cannel, will together make 19-candle gas.

71·627 per cent. of 10·060 = 7205·7
28·373 „ 11·580 = 3285·6

So the mixture will produce 10·491 cubic feet.
Log. 10·060 = 4·00259798
Log. 71·625 = 1·8550785

Log. 720570 = 5·85767648

Log. 11·580 = 4·0637086
Log. 28·373 = 1·4529053

Log. 328560 = 5·5166139

and 10·491 × constant 10·62*d.* = 111·4*d.*
7·205 × „ 4·374. = 31·5.

Therefore the 3285 feet of cannel gas are worth 80·0*d.*

	£	s.	d.
$\frac{11{\cdot}580 \times 80}{3285} = 282d.$, or	1	3	6
Carbonizing, etc., expenses, difference between 11,580 and 10,333	0	0	8
Tar, 2·16 lbs., at 1*s.*	0	2	2
Coke, 1400 lbs., at 4*d.*	0	4	8
So this cannel would be worth	1	11	0

when the standard cannel sold for 25*s.* delivered.

Mr. Longworth, formerly of Dukinfield, states that cannel nuts produce 9875 cubic feet of 18·25-candle gas, and 1500 lbs. of coke per ton. These nuts are produced from a good cannel producing between 10,000 and 11,000 of 22-candle gas. The fall in illuminating power is due to there being only between 50 and 60 per cent. of cannel in them, the rest being a coal (not a gas coal), and clay, the large weight of *coke* is not in their favour as a *cannel.*

We shall now compare this cannel with the standard cannel to make 19-candle gas.

$$\begin{array}{rcl} 19 - 18{\cdot}25 & \searrow\!\!\!\nearrow & 2{\cdot}30 \\ 21{\cdot}3 - 19 & \nearrow\!\!\!\searrow & 0{\cdot}75 \end{array}$$

$$\therefore \frac{230}{9875} \text{ nuts} + \frac{75}{10{\cdot}333} \text{ of cannel will make 19-candle gas.}$$

Log. 230 = 2·3617278
Log. 10333 = 4·01422643

Log. 23766000 7·37595423

Log. 75 = 1·8750613
Log. 9875 = 3·9945371

Log. 914020 = 5·8695984
23766000

24680020 : 100 :: 23766000 : x

Log. 23766000 = 7·37595423
Log. 100 = 2·00000000

9·37595423

Log. 24680020 = 7·3923452

Log. 96·296 = 1·98360903 and

100
96·296
3·704

per cent. 9875 = 9509·2
„ 10·333 = 382·73

So the mixture will produce 9891·93

Log. 9875 = 3·9945371
Log. 96·296 = 1·98360903

Log. 9509,20 = 5·97814613

Log. 10·333 = 4·01422643
Log. 3·704 = 0·5686710

Log. 382,73 = 4·58289743

9892 cubic feet × constant 10·62 = 105*d.*, but 382·73 cubic feet, costing 19·09*d.* were used in the mixture which × by each other = 7·30*d.*

105
minus 7·3

97·7 will therefore represent the value of the 9509·2 cubic feet used in the mixture.

	s.	*d.*
$\frac{9875 \times 97\cdot7}{9509\cdot2} = 101\cdot4d.$ or	8	5½
1500 lbs. of coke, at 3*d.*	3	9
Tar, say	1	0
Ammonia water, say	0	9½
	14	0
Less for carbonizing differences	0	4
So that these nuts are worth	13	8

when the standard cannel sold for 25*s.* per ton delivered, but these nuts were sold at considerably more, showing a *loss* from their use.

The absurdity of mixing laboratory and practical tests of coal or cannel for purposes of comparative commercial valuation, without due qualification, will be apparent, otherwise incorrect money values will be assigned.

Of exceptionally flattering reports, ill-borne out in practice, or even with testing, further comment is unnecessary.

Trusting this, my last contribution on this subject may be found an advance on what I have formerly written respecting this matter, and that it will be found easier and simpler of application than that which has preceded it, I shall pass on to the consideration of a question closely allied to the one discussed: "The cost of adding a candle to the illuminating power of gas." At the end, a graphic method of delineating makes and illuminating power is added for those who may care to enter into a geometrical investigation of this subject, and from the preceding valuation of gas in coals and cannels, I have, in the last papers, deduced a much simpler method of valuation, which I commend to those who desire simplicity in method, which is, in this case, also compatible with accuracy of results.

A METHOD WHEREBY THE COST OF ADDING A CANDLE TO THE ILLUMINATING POWER OF GAS MAY BE ASCERTAINED.

First select the material (coal and cannel) from which it is purposed the gas should be made, which should be that from which the gas can be manufactured most economically, and state the least price for these materials *delivered*, for both coal and cannel, as also the production in cubic feet per ton of each, and the illuminating power which each will separately produce.

Then the price paid in each case, being the sum of all the products which each will separately produce, minus the impurities, plus in the case of the one which yields the larger return per ton of the difference in carbonizing, wages, and other items previously specified; this being the case it is quite unnecessary to enter into a further analysis of their separate products, the price in each case being a fair charge for their sum; we have therefore in the first instance only *three* items to consider—illuminating power, volume produced per ton, and the price of each delivered, from which the percentages required to manufacture the two qualities differing by one candle, are to be manufactured.

In the following case I shall select the same cannel I have formerly used as a standard of comparison; it produced 10,333 cubic feet, and at a certain date at a particular gasworks was delivered at 24*s.* 6*d.* per ton.

The coal (*a Burgy*, which in Lancashire means the get *after* the round coal has been screened out of it), produced 9810 cubic feet of 15·1-candle gas, and cost 10*s.* 6*d.* delivered. (*Burgy* is usually carbonized with *four-hour work*, as thereby the gas is better driven off with high heats, and the "tail end" of the charge (carbonic oxide) does not do so much injury to the gas as would be the case with *six*-hour work.)

Next ascertain the percentages required, say in this case, to manufacture 17- and 18-candle gas.

First, 17-candle gas.

$$\begin{array}{rcl} 17 - 15{\cdot}1 & \times & 4{\cdot}3 \\ 21{\cdot}3 - 17{\cdot}0 & & 1{\cdot}9 \end{array}$$

Therefore $\frac{43}{9810}$ of this coal + $\frac{19}{10333}$ of this cannel will make 17-candle gas.

I shall here also use logarithms, as being simpler and not so liable to prove inaccurate.

$$\begin{array}{rl} \text{Log. } 43 & = 1{\cdot}6334685 \\ \text{Log. } 10{\cdot}333 & = 4{\cdot}01422643 \\ \hline \text{Log. } 444330 & = 5{\cdot}64769493 \end{array}$$

$$\begin{array}{rl} \text{Log. } 19 & = 1{\cdot}2787536 \\ \text{Log. } 9810 & = 3{\cdot}9916690 \\ \hline \text{Log. } 186390 & = 5{\cdot}2704226 \end{array}$$

$$444330 + 186390 = 630720$$

$$630720 : 100 :: 444330 : x \text{ or } 70{\cdot}447$$

$$\begin{array}{rl} \text{Log. } 444330 & = 5{\cdot}64769493 \\ \text{Log. } 100 & = 2{\cdot}00000000 \\ \hline \text{Log. } 70{\cdot}447 & = 1{\cdot}84786133 \end{array}$$

$$\begin{array}{r} 100 \\ \hline 29{\cdot}553 \end{array}$$

so that 70·447 per cent. of this coal, plus 29·553 per cent. of this cannel, will make 17-candle gas.

The makes for the mixture will be found as follows:

$$\begin{array}{lrl} 70{\cdot}447 \text{ per cent. of } & 9810 & = 6910{\cdot}9 \\ 29{\cdot}553 \quad ,, & 10{\cdot}333 & = 3053{\cdot}7 \\ \hline & & \ 9964{\cdot}0 \text{ cubic feet.} \end{array}$$

By logarithms.

Log. 70·447 = 1·84786133
Log. 9810 = 3·9916690

Log. 691090 = 5·83953033

Log. 29·553 = 1·4706016
Log. 10·333 = 4·01422643

Log. 305370 = 5·48482803

The price of the coal equals 10*s.* 6*d.* = 126*d.*, and the cannel 24*s.* 6*d.* = 294*d.*

70·447 per cent. of 126*d.* = 88·767*d.*

Log. 70·447 = 1·84786133
Log. 126 = 2·1003905

Log. 88·767*d.* = 3·94825183

Log. 29·553 = 1·4706018
Log. 294 = 2·4683473

Log. 86·886 = 3·9389491

So that this mixture will cost

88·767*d.* for coal,
and 86·886*d.* for cannel,

or 175·653*d.* for the 9964 cubic feet of 17-candle gas;
and $\frac{175{\cdot}653d.}{9964}$ = 17·627*d.* per 1000 at the station metre which is the value sought for 17-candle gas.

Log. 175·653 = 2·2446482
Log. 9,964·6 = 0·9984599

Log. 17·627 = 1·2461883

And now we shall proceed to find the value for 18-candle gas.

$$\begin{array}{lcl} 18 - 15{\cdot}1 & & 3{\cdot}3 \\ & \times & \\ 21{\cdot}3 - 18 & & 2{\cdot}9 \end{array}$$

Therefore $\frac{33}{9810}$ of this coal + $\frac{29}{10 \cdot 333}$ of this cannel will make 18-candle gas.

Log. 33 = 1·5185139
Log. 10·333 = 4·01422643

Log. 429280 = 5·63274033

Log. 29 = 1·4623980
Log. 9810 = 3·9916690

Log. 284490 = 5·4540670

429280 + 284490 = 713770
713770 : 100 : : 429280 : *x*

Log. 429280 = 5·63274033
Log. 100 = 2·00000000

7·63274033

Log. 713770 = 5·8535583

Log. 56·129 = 1·74918203
100

43·8871

So that in this case 56·129 per cent. of this coal, and 43·8871 per cent. of this cannel will be required to make 18-candle gas, and the makes will equal 10·040 cubic feet per ton.

For 56·12 per cent. of coal × 9810 = 5506 cubic feet.
43·88 „ cannel × 10·333 = 4534 „

Together 10·040

Log. 56·12 = 1·74918203
Log. 9810 = 3·9916690

Log. 550620 = 5·74085103

Log. 43·88 = 1·6422666
Log. 10·333 = 4·01422643

Log. 453410 = 5·65649203

56·12 per cent. of 126*d.* = 70·72*d.*
43·88 „ 294*d.* = 129·01*d.*

So the 10·040 cubic feet cost 199·73*d.*

$\frac{199 \cdot 73}{10 \cdot 040}$ = 19·893, which is the cost *in the coal* and cannel for 18-candle gas made from this mixture; 19·892*d.* the cost of 18-candle gas — 17·627, the cost for 17-candle gas equals 2·364*d.*, which is the difference in the price between 17- and 18-candle gas for material *alone*; but in the case of the 18-candle mixture, the make exceeds that for 17-candle gas, but they are so nearly alike that no estimate for difference in wear and tear, etc., *except* for *carbonizing* wages, can be allowed. This cost per ton for Lancashire equals 5*s.* for 2 ton 2 cwt., equal 28·57*d.* per ton.

The difference per 1000 at the station meter on these two productions equals 2·8672 — 2,8456*d.*, a difference of ·0226*d.*, which reduces the cost of the difference between 17- and 18-candle gas produced from these materials to 2·364*d.* — ·0226, or 2·341*d.*; but unless the price were reduced proportionally with the rise in quality, the public would use less of 18-candle gas than of 17, and if there was no increase of consumption (annual) such as would make up for this loss, dividend would suffer unless this loss were also added to *cost;* if the dividend rate amounted to say 1*s.* at the station meter (it would of course be more at the consumer's meter to allow for condensation and leakage), and if the consumption were decreased in the inverse ratio of 17 to 18, then $\frac{12d. \times 18}{17}$ = 12·706, a difference of 0·706*d.* in dividend rate, so that 2·341 + 0·706 = 3·047,—so that 3*d.* would in this case show a near approximate to the cost of adding one candle to the illuminating power of the gas.

Mr. George Livesey, of the South Metropolitan, gives the value as 2½*d.* in his case, which is a near approximate to this independent calculation, which in this estimate amounts to £12 10*s.* per million at the station meter.

On the other hand, if there was an increase in consumption, without having to incur the expenditure of additional capital, 2½*d.* would represent the approximate cost of adding one candle to the illuminating power of 17-candle gas at the station meter. Again, if the price of adding a candle to the illuminating power of the gas was found to equal 3*d.*, and the leakage and condensation amounted to say ten per cent., the cost of the candle at the consumer's meter would equal $\frac{3d. \times 10}{9} = 3 \cdot 33d.$

If a decrease in consumption accompanied the increase in illuminating power, which it is probable would be the case, unless the selling price of the gas were correspondingly lowered, there are sundry charges which would tend still further to increase cost to consumer, or loss to the gas company, such as the charges for watering and recording the statement of meters, and the cost of maintaining a staff of officers, presumably receiving no less remuneration. (Temporary increases of illuminating power above normal or statutory requirements also tend to produce a like result.) These changes not differing materially from those incurred from using the lesser illuminating power.

On the other hand, no greater mistake can be made than to attempt to increase profits at the expense of the illuminating power of the gas, thus driving the consumer to the use of other means of illumination—to the loss of the revenue of a gas company—with inferior qualities of coal and cannel, *generally much* over-priced; it is difficult for a manager to keep down expenses if the gas be maintained at its full illuminating power, and he be thereby compelled to use large percentages of such cannel to keep it up to the standard; as good a remedy as any is a weekly, fortnightly, or monthly statement, not merely of makes, etc., but of *costs*, of material reduced to the basis of 1000 cubic feet at the station meter, and including all costs for carbonizing, purifying, and all other expenses which can be averaged from the preceding year's accounts, such as salaries, interest, depreciation, repairs and renewals, which, made out according to regular form, would soon show how considerable sums might be frittered away on dear and unsuitable material.

GRAPHIC METHODS OF REPRESENTING THE ILLUMINATING POWER, AND THE PRODUCTION PER TON OF DIFFERENT MIXTURES OF COAL AND CANNEL, ALSO A GRAPHIC MODE OF OBTAINING THE PERCENTAGES OF COAL AND CANNEL REQUISITE TO PRODUCE ANY QUALITY OF GAS INTERMEDIATE TO THE QUALITIES THAT COAL OR CANNEL WILL SEPARATELY PRODUCE.

A line may be made of such a length as shall express the quantity of gas made from any particular coal or cannel, and another line may be made to represent the illuminating power of either this coal or cannel, and the rectangle of the two lines may thus be made to represent the production of quantity of gas into quality, and another coal or cannel producing other quantities and qualities may conveniently be compared with this rectangle, by placing the two rectangles together so that two sides of the one shall lie along the sides of the other. The enclosed space between the two will represent the difference of the difference of the two qualities.

Thus, in this diagram (see fig. 1), let the rectangle I B E G represent the number of candles I G (= 22) multiplied by the production per ton this cannel produces = G E = 10,000 cubic feet, and let the rectangle G H A F represent the illuminating power multiplied by the production of a coal producing 9000 cubic feet (= G F :) of 12-candle gas = H G. Then the difference of the areas of these two rectangles, = the rectangles I B C H + A C E F, would represent the amount of this difference of the differences.

In diagram (fig. 2), let the figure A D B C represent the figure A D B C in the diagram already referred to (fig. 1), and divide it horizontally into such equal parts as shall represent the equal divisions of the candles 12, 13, 14, 15, &c., &c., and let the line A C = 1000, the difference between 9000 and 10,000 cubic feet.

The cannel is one which produces 10,000 cubic feet of 22-candle gas, and the coal produces 9000 cubic feet of 12-candle gas.

Three-fourths cannel and one-fourth coal will, therefore, produce:

1 × 9 = 9, and 9 × 12 = 108

3 × 10 = 30, and 30 × 22 = 660

4)39 768(19·69

9·750 feet of 19·69-candle gas.

Half cannel and half coal will produce:

9 × 12 = 108

10 × 22 = 220

2)19 328

9·500 feet of 17·26-candle gas.

And three of coal to one of cannel will produce:

3 × 9 = 27, and 27 × 12 = 324

1 × 10 = 10, and 10 × 22 = 220

4)37 544

9·250 feet of 14·7-candle gas.

From this we find that the following numbers will represent the productions per ton of these several mixtures:—

Cannel.	Coal.		
100 per cent.	0 per cent.	= 10000 cubic feet of	22-candle gas.
75 „	25 „	= 9750 „	19·69 „
50 „	50 „	= 9500 „	17·26 „
25 „	75 „	= 9250 „	14·70 „
0 „	100 „	= 9000 „	12·00 „

Lay off co-ordinate lines, which shall represent these results —that is, let B represent the *locus* or position of the point which shall represent 10,000 cubic feet of 22-candle gas; H, 9750 cubic feet of 19·69-candle gas; G, 9500 cubic feet of 17·26-candle gas; F, 9250 cubic feet of 14·70-candle gas; and A, 9000 cubic feet of 12-candle gas. Draw the straight diagonal line A B and it will be found that it does not pass through these points; but the curved line which will pass through them will be the line A F G H B. It will be seen that 22 – 12 = 10 will be the sum of the series of candles here represented, and that 10,000 – 9000 = 1000 will be the sum of the differences of the productions = A C. The intermediate values could be ascertained from this and other data, from which the nature of this curve and series could be ascertained, which, formulated, would give expression to the ratios of each difference of a candle shown on this curve—but at present we shall confine ourselves to the demonstration of certain other peculiarities of this curve.

Now, if these several points, A F G H B, represent a curve which shall at these several points represent the illuminating power and the production per ton of these several mixtures from various percentages of this coal and cannel, this curve must also determine the *locus* for all other productions per ton and all illuminating powers within the limits $\frac{A}{B}$, so that $\Delta' \; \Delta''$ $\Delta''' \; \Delta''''$ and K will respectively represent the values of 13, 14, 15, 16, and 17-candle gas; and the vertical lines drawn from these points will limit the length of lines which shall represent the production per ton the mixtures producing those several qualities of gas will produce, and the proportions or percentages of these mixtures can be determined in a very simple manner. For it will be observed that 9500 is an arithmetical mean between 10,000 and 9000, and that

$$\frac{(9 \times 3) + 10}{4} = 9250, \text{ and } \frac{(10 \times 3) + 9}{4} = 9750$$

and that these are three such numbers as divide the line 10,000 – 9000 = 1000 into four equal quantities or parts. Vertical lines drawn from these four equal divisions, will, of course, divide the diagonal or straight line drawn from any scale of equal parts into four equal divisions, and as this line is divided into 100 equal parts, it follows that each of these divisions will divide it into four equal parts containing 25 divisions each; so that for division O, if the proportion be taken *inversely*, 25 per cent. of this cannel, mixed with 75 per cent. of this coal, will produce 9250 cubic feet of 14·7-candle gas. But what is true of these four divisions will also be true of all others; therefore, vertical lines drawn from any candle line which intersects the curve will enclose a rectangle, whose length will express the amount of the make, and whose breadth shall represent the illuminating power the mixture will produce, and the percentage of coal and cannel required to manufacture this quality can be read off at the point where the vertical line intersects this scale.

Thus, for 13-candle gas: the production per ton can be measured from the vertical line passing through 9·1 in the scale, which distance can either be measured with a diagonal scale, or from the line of lines on the limbs of a sector, or, in the case assumed, from the diagonal scale drawn.

Consequently, 9·1 per cent. of cannel producing 10,000 cubic feet of 22-candle gas + 90·9 per cent. of coal producing 9000 cubic feet of 12-candle gas will together produce 9091 cubic feet of 13-candle gas.

For 9·1 × 10 = 910, which multiplied by 22 = 20020
And 90·9 × 9 = 8181, „ „ 12 = 98172

9091 118192

And 9091)118192(13
9091

27282
27273

Now, the difference between all the values of the various products produced from 9·1 per cent. of this cannel, and 90·9 per cent. of this coal—the mixture producing 9091 cubic feet of 13-candle gas, and the various costs involved in manufacturing from this mixture, compared with the same charges for the coal producing 9000 cubic feet of 12-candle gas, would form a basis from which the value of a candle could be accurately ascertained.

We shall now inquire into the nature of another curve obtained in a similar manner to that just enunciated.

Thus, let the productions per ton be the converse of those used for the last demonstration — namely, cannel producing 9000 cubic feet of 22-candle gas, and the coal producing 10,000 cubic feet of 12-candle gas. In this case, the nature of the curve has been ascertained for seven points.

Cannel	0	25	33	50	66	75	100
Coal	100	75	66	50	33	25	0

These percentages would be represented by the line—

D, T, J, K, L, M, N, C,

this curve being concave, while the other was convex; and it will be observed that they intersect at the point π, which is a point so situated that on the two opposite suppositions—either that coal produces 9000 cubic feet of 12-candle gas, and cannel 10,000 cubic feet of 22-candle gas, or that coal produces 10,000 cubic feet of 12-candle gas, and the cannel produces 9000 cubic feet of 22-candle gas—would represent the position of a point, where 9475 cubic feet of 17-candle gas would be manufactured from 47·5 per cent. of the cannel, producing 10,000 cubic feet of 22-candle gas, *plus* 52·5 per cent. of a coal producing 9000 cubic feet of 12-candle gas; or this same quality and quantity—17-candle gas and 9475 cubic feet per ton—could also be produced from 52·6 per cent. of a cannel producing 9000 cubic feet of 22-candle gas, and 47·4 per cent. of coal producing 10,000 cubic feet of 12-candle gas—results which have been obtained from using the diagonal scale, but which will be found to nearly correspond to those which might have been obtained by calculation.

Thus:

$$
\begin{array}{r}
10 \times 22 = 220, \text{ and } 220 \times 47{\cdot}4 = 104280 \\
9 \times 12 = 108, \text{ and } 108 \times 52{\cdot}6 = \underline{56808} \\
161088
\end{array}
$$

$$\text{And } \frac{161088}{17 \text{ candles}} = 9475 \text{ cubic feet.}$$

And:

$$
\begin{array}{r}
9 \times 22 = 198, \text{ and } 198 \times 52{\cdot}6 = 10414{\cdot}8 \\
10 \times 12 = 120, \text{ and } 120 \times 47{\cdot}4 = \underline{5688{\cdot}0} \\
16102{\cdot}8
\end{array}
$$

$$\text{And } \frac{161028}{17} = 9472 \text{ cubic feet.}$$

DEMONSTRATION, THAT THE LINES A B AND D C IN FIG. 2 MUST BE CURVES, AND THAT THE DIAGONALS CANNOT REPRESENT THE POINTS WHERE THE CO-ORDINATES REPRESENTING THE ILLUMINATING AND PRODUCTIVE POWER OF THESE MIXTURES MEET.

We have shown how the values of the lengths of the co-ordinates, expressing the values of the candles and the returns per ton, may be determined from the selection of a few cases, and calculating their values from the values assigned to the particular coal and cannel selected.

We shall now proceed to examine a constructive method of obtaining these values, which might conveniently be substituted for the arithmetical formulæ for obtaining them; although, unless large scales were used, they could not be applied to obtain these numbers so accurately as they might be found by calculation.

In fig. 3, let the rectangle H J M L represent the illuminating power of this coal, multiplied by its productive power; that is, let M J = 12 candles: and L M = 9000 cubic feet, and let the rectangle M B D O represent the illuminating power of this cannel multiplied by its production per ton; that is, let M B = 22 candles, and M O = 10,000 cubic feet.

Bisect L M and M O, then will P N be equal to the production of half a ton of this coal, *plus* half a ton of this cannel. Draw the vertical lines P A and N C, and from A—the point where D B produced intersects the vertical line P A—draw the diagonal line A K; and at the point where it cuts M B, at the point U, draw E G, parallel to P N, then will the rectangle P E G N represent the production per ton, multiplied by the illuminating power of half and half of this coal and cannel; for the rectangle E U J I is equal in area to the rectangle B C G U, therefore P I J M + M B C N is equal to P E G N.

Make J W = I J, and draw the straight line A W; it will bisect the line B J in the point F, and, had the cannel produced 9000 cubic feet as well as this coal, would have shown that the diagonal line which joined the values of the candles would have been straight, and necessarily vertical; but the greater the divergence of the makes per ton, the greater will be the curvature of the curve which joins their extremes, and it will be evident that the converse will also be true—that the nearer the makes per ton approach each other, the nearer will this curve approach to a straight line.

M U will, therefore, represent the value of the illuminating power of this mixture of half and half; and had the makes been equal, M F would have represented their value, so that F U will represent the vertical difference between the values of the lengths of the ordinates, showing the value for the diagonal straight line and the curved line.

Doubling or halving, or taking any other multiple or submultiple of these values, will not alter the relations they bear to each other, for let A B be bisected in the point Q, and B C be bisected in the point R, then will the diagonal line, Q V, pass through the point U, and the value of J U may therefore be found from either of the following formulæ—

$$KJ : JU :: KI : IA$$

$$\text{or, } VJ : JU :: VT : TQ$$

Or the value of M V (the illuminating power of the gas produced from the mixture) may be obtained from the trigonometrical ratios

$$\sin \text{angle } AKI = \frac{AI}{IK}$$

J U K being a right-angled triangle : the angle at U = 90 − sin U K J

$$\frac{\text{and } JK \text{ (which is known)} \times \sin UKJ}{\sin KUJ} = FJ$$

and F J + J M = ordinate.

In the same manner, it could be proved that F N and M F in fig. 4 would represent the values of the production per ton, and the illuminating power of a mixture of two of this coal to one of this cannel, and F J must therefore be the measure of a point beyond the straight diagonal line; for M N is greater than one-half of P M, and this must be true of all other points in the curve with the exception of its extremes.

Make J W = I J, and draw the straight line A W; it will bisect the line B J in the point F, and, had the cannel produced 9000 cubic feet as well as this coal, would have shown that the diagonal line which joined the values of the candles would have been straight, and necessarily vertical; but the greater the divergence of the makes per ton, the greater will be the curvature of the curve which joins their extremes, and it will be evident that the converse will also be true—that the nearer the makes per ton approach each other, the nearer will this curve approach to a straight line.

M U will, therefore, represent the value of the illuminating power of this mixture of half and half; and had the makes been equal, M F would have represented their value, so that F U will represent the vertical difference between the values of the lengths of the ordinates, showing the value for the diagonal straight line and the curved line.

Doubling or halving, or taking any other multiple or submultiple of these values, will not alter the relations they bear to each other, for let A B be bisected in the point Q, and B C be bisected in the point R, then will the diagonal line, Q V, pass through the point U, and the value of J U may therefore be found from either of the following formulæ—

$$K J : J U : : K I : I A$$

$$\text{or, } V J : J U : : V T : T Q$$

Or the value of M V (the illuminating power of the gas produced from the mixture) may be obtained from the trigonometrical ratios

$$\sin \text{ angle } A K I = \frac{A I}{I K}$$

J U K being a right-angled triangle : the angle at U = 90 − sin U K J

$$\frac{\text{and } J K \text{ (which is known)} \times \sin U K J}{\sin K U J} = F J$$

and F J + J M = ordinate.

In the same manner, it could be proved that F N [illegible]

[illegible]

1

4

2 1¼

7 7¾

en

t. –

= 1 1

t 17 3

PROPORTIONAL METHODS OF ASSIGNING VALUES TO THE GAS PRODUCED FROM COAL OR CANNEL.

The following method of valuing the gas produced from a coal or cannel follows as a corollary from a number of the preceding principles and formulæ. Divide the whole of the values of the gas produced from the various coals and cannels in the first series of valuations by their several makes per ton. Then the following series of prices and qualities corresponding to them per 1000 will represent these values for that series of coal and cannel valuations. (See Fig. 9.)

Candles.	Plus. *d.*	Minus. *d.*
11·9	..	17·9
15·9	..	1·83
17·3, standard coal	3·87	..
18·5, intermediate value	8·69	..
19·1	9·39	..
20·2	15·43	..
21·3, standard cannel	19·98	..
27·1	49·4	..
47·0	131·5	..

Draw a line A B, and from it lay off co-ordinates to represent these several prices and candle values. One scale may be used to measure the one, and another the other, or one scale may be used for both.

Then it will be seen on inspection, that in many places a straight line passes through the series of co-ordinates, from which the inference to be drawn is—that the commercial value of candle powers produced from gas-making materials per 1000, is proportional to the two values of the standard coal and cannel candle, and the distance in candles from origin.

The difference between the standard cannel candle and the standard coal candle in this case equals 21·3 − 17·3 = 4 candles—the difference in price equals 19·98 − 3·87 = 16·11. $\frac{16\cdot 11}{4} = 4\cdot 028d.$ will therefore represent the increment of increase or decrease from the locus, when the candle power is worth O, and will represent the constant for these values to be used in this system of valuation: if the origin A be selected to obtain the extreme minus values, this can easily be done from the triangular ratios. In this case I prefer to consider origin as located at D, the value in candle power equal to O *d.* That value will be found as follows: 16·11 : 4 : : 21·3 : x or 5·28; so that 21·3 − 5·28 = 16·02-candle power will in this series represent the locus or position when the candle power for these valuations is to be valued at *nought* (0), on the cannel candle side of this locus, they are + or positive values − on the other, negative or minus (−).

I shall now illustrate how coals and cannels may be valued from this simple method of valuation.

L . . . *sound* coal produces 10,820 cubic feet of 17·4-candle gas, 1530 lbs. of hot coke, 178 lbs. of tar, and 151 lbs. of ammonia water, having a strength equal to 6° Twaddel, and the gas produced from this "sound" coal required 78 lbs. of unslacked lime for its purification.

17·4 candle − 16·02 (origin value when the candle value equals 0) = 1·38 candle, which is the *excess* of illuminating power in the gas produced from this coal, which has a + value.

$$10\cdot 82 \times 1\cdot 38 \times 4\cdot 028 = 60\cdot 14d. \text{ or } 5s.\ 1d.$$

So that the value of this coal will be found as follows:

		s.	*d.*
10·82 × 1·38 × 4·028 = 60·14*d.*	=	5	1
151 lbs. ammonia water 6° T. × ·892 = 1·346*s.*	=	1	4
178 lbs. tar at 1·2*s.* = 2·136*s*	=	2	1¼
15·30 lbs. coke at 6*d.* = 91·8*d.*	=	7	7¾
Difference in carbonizing, etc., expenses between 10,820 and the standard coal 9,240 = 7*s.* 3*d.* − 6*s.* 2*d.*	=	1	1
So that		17	3

represented the value of this coal delivered when the standard coal was selling for 13*s.* 9*d.*

I shall now find the value of a cannel producing 9,676 cubic feet of 20·3-candle gas; it also produced 1460 lbs. of coke, 240 lbs. tar, and 105 lbs. liquor, having a strength equal to 5° Twaddel.

First the gas.

		s.	*d.*
20·3 − 16·02 (origin value) = 4·28,			
4·28 × 9·676 × 4·028 = 166·79*d.*	=	13	10¾
240 lbs. tar at 1*s.* = 2·4	=	2	5
105 lbs. ammonia water 5° T. × ·624 = ·655	=		8
Coke 14·6 at 4*d.*..	=	4	10¼
		21	10
Less difference, carbonizing expenses, between cannel producing 10,333 and 9,676 = 6*s.* 11*d.* − 6*s.* 5*d.*..	=		6
So this cannel was worth		21	4

delivered when the standard cannel sold for 24*s.* 6*d.*

I shall now bring this paper to a close by illustrating a case where the *minus* (−) value is to be used.

A coal produces 7,260 cubic feet of 15·1-candle gas − 1545 lbs. of coke, 130 lbs. tar, and 165 lbs. ammonia water, having a strength equal to 4½° Twaddel.

First find the value of the gas.

$$16{\cdot}02 - 15{\cdot}1 = 0{\cdot}92.$$

7·26 × 0·92 × 4·028 = 26·9*d.*, say 27; so that the gas produced from this coal is worth 2*s.* 3*d.* *less than nothing.*

Difference in carbonizing, &c., expenses between this and the standard coal = 9*s.* 2*d.* − 7*s.* 3*d.* = 1*s.* 11*d.*

2*s.* 3*d.* + 1*s.* 11*d.* = 4*s.* 2*d.* is therefore the sum which is to be deducted from the sum of the values of the secondary products.

		s.	*d.*
Coke, 15·45 lbs. at 5*d.* = 77·25*d.*	=	6	5¼
Tar, 130 × 1·2*s.* = 1·56*s*..	=	1	6½
Ammonia water, 1·65 lbs. × ·491	=		9½
		8	9¼
less		4	2
So this coal is worth only		4	7¼

when the standard coal sold for 13*s.* 9*d.*; but this coal sold for 12*s.* delivered, showing a loss from its use equivalent to nearly 8*s.* per ton purchased.

The method of valuing after this system consists first in ascertaining for the standard coal and cannel the cost price of the gas in each, and dividing this cost price by the makes; the remaining portion of the system I have demonstrated and illustrated in this paper, and the diagram accompanying it. It will be seen that there is a choice of two methods of valuing; that which is most suitable for practice, we shall allow others to determine.

Fig. No. 7 gives a graphic delineation of the series of co-ordinates representing the value per 1000 of the various qualities of gas produced from the coals and cannels of the *second* series of valuations. It will be observed that the line formed by their junction is straight, and in the *preceding* calculations it is assumed to be *straight.* The method is therefore applicable not only to those qualities of coal or cannel which produce qualities of gas intermediate to, or not greatly exceeding, either of these limits of illuminating power, but for all values above or below these limits; a line may be constructed from the two standard qualities of gas, the *ordinates* of which might be substituted for the constant, by multiplying the value of this ordinate, when it corresponds with the illuminating power in the coal or cannel to be valued by the production per ton, which will represent the commercial value of the gas the material produces.

An additional proof of the correctness of the preceding method of valuing the gas produced from coal or cannels, yielding qualities of gas intermediate to the qualities produced from the standard coal or cannel, is given in the following demonstration.

Suppose that, after deducting the sum of the values of the secondary products produced from the standard coal, plus or minus, as the case may be, the value of the difference for carbonizing, wages, renewals, repairs, interest, etc.—that the value of the 15-candle gas produced from this coal was equal to 3*d.* per 1000, and for the standard cannel producing 22-candle gas, that the value of its gas per 1000 equalled 20*d.* per 1000, then the following series of valuations would represent the non-fractional series of intermediate values.

$$\begin{array}{lcrcrcrl}
 & & & & d. & & d. & \\
15 - 16 & \diagdown & 6 & \times & 3 & = & 18 & \\
22 - 16 & \diagup & 1 & \times & 20 & = & 20 & \\
\hline
 & & 7 & & &) & 38 & (5{\cdot}42 \text{ per } 1000 \\
15 - 17 & \diagdown & 5 & \times & 3 & = & 15 & \\
22 - 17 & \diagup & 2 & \times & 20 & = & 40 & \\
\hline
 & & 7 & & &) & 55 & (7{\cdot}85 \quad ,, \\
15 - 18 & \diagdown & 4 & \times & 3 & = & 12 & \\
22 - 18 & \diagup & 3 & \times & 20 & = & 60 & \\
\hline
 & & 7 & & &) & 72 & (10{\cdot}28 \quad ,, \\
15 - 19 & \diagdown & 3 & \times & 3 & = & 9 & \\
22 - 19 & \diagup & 4 & \times & 20 & = & 80 & \\
\hline
 & & 7 & & &) & 89 & (12{\cdot}71 \quad ,, \\
15 - 20 & \diagdown & 2 & \times & 3 & = & 6 & \\
22 - 20 & \diagup & 5 & \times & 20 & = & 100 & \\
\hline
 & & 7 & & &) & 106 & (15{\cdot}14 \quad ,, \\
15 - 21 & \diagdown & 1 & \times & 3 & = & 3 & \\
22 - 21 & \diagup & 6 & \times & 20 & = & 120 & \\
\hline
 & & 7 & & &) & 123 & (17{\cdot}57 \quad ,,
\end{array}$$

Lay off these co-ordinates, and it will be found that the line which joins the extremes is straight. See Fig. 8, from which the inference to be deduced is that the value of the various qualities of gas intermediate to the two extreme values of the standard coal and cannel candle, is *proportional* to the quality of gas a material produces, measured from origin.

Thus, supposing a coal produces 9,500 cubic feet of 16-candle gas—the ordinate for 16 candles equals 5·4*d.*, which × 9·5 =

51·3*d.* = 4*s.* 3½*d.*, which would represent the value of the gas produced—which sum, *plus* the value of the products—plus or minus the difference in the costs of the carbonizing, etc., expenses, would represent the comparative value of this coal. This diagram shows a difference of 2·428*d.* per candle per 1000.

As a further extension of the demonstration that the value of the illuminating power is directly proportional to its distance from the position where the value equals 0. Let Fig. 8 represent values of costs and illuminating power similar to those chosen for the last example. Then half a thousand of 15-candle gas costing 3*d.* per thousand, plus half a thousand of 29-candle gas worth 37*d.*, will together produce 1000 cubic feet of 22-candle gas worth 20*d.* Or again, two-thirds of a thousand of 15-candle gas costing 3*d.* per 1000, plus one-third of a thousand of 36-candle gas costing 54*d.* per 1000, will together produce 1000 cubic feet of 22-candle gas, costing 20*d.* per 1000. But these illuminating powers and prices are the triangular ratios shown in the diagram, which shows that the line passing through the co-ordinates is *straight* for values *exceeding* the standard cannel values. Therefore the *plus or minus* value of the candle per 1000 is proportional to its distance from the origin or position where the candle values equal 0. In this case the constant will equal $\frac{17d.}{7 \text{ candles}}$ = 2·428*d.* per candle per 1000.

Now, suppose a cannel produced 11,000 cubic feet of 30-candle gas, 11 × 2·428*d.* × (30 − 13·76) = 443·73*d.* = 36*s.* 1¾*d.* would represent the value of the gas this cannel produced; which sum, plus the sum of the values of the secondary products, would represent the comparative value of this cannel when compared with the standard coal and cannel whose values I have assumed to be 3*d.* for the coal, and 20*d.* for the cannel, per 1000.

One more example of a cannel whose illuminating power exceeds that of the standard cannel may suffice to bring this series of comparative values to a conclusion.

Suppose the standard cannel produced 10,000 cubic feet per ton, and that another cannel produced 10,916 cubic feet of 22·7-

candle gas, 14·55 lbs. of coke, 201 lbs. of tar, and 65 lbs. ammonia water, having a strength equal to 4° Twaddel. Then the value of the gas so produced would equal

		s.	d.
10·916 × 2·428 × (22·7 − 13·78) = 236·9d.	=	18	1
14·55 lbs. coke at 4¼d.	=	5	1
201 lbs. tar. at 1s. per cental	=	2	0
65 lbs. ammonia water, at ·557d.	=		3
Carbonizing, &c., differences 10,000 and 10,916	=		7
So this cannel would be worth £1		6	0

when the standard coal gas (15-candle) was worth 3d. per 1000, and the standard cannel gas (22-candle) was worth 20d.

AN EXEMPLIFICATION OF HOW THIS PROPORTIONAL METHOD OF VALUATION MAY BE APPLIED IN PRACTICE.

So that there be no misapprehension as to how this proportional method of valuing the gas produced from coals or cannels is to be applied in practice, I have in this final paper given a few examples, such as may occur in practice, and have shown how the principles previously enunciated are to be applied to this concise and easy mode of valuing.

Suppose a Gas Company have been offered for purchase the coals and cannels here valued. From among these materials select two (see Corollary I., page 89): a coal of fair quality, and a cannel of good quality, to represent standards for comparison; with which the remainder are to be compared. For instance.

STANDARD COAL.

A coal produces 9810 cubic feet of 15·1-candle gas, 120 lbs. of tar, 141 lbs. of ammonia water, having a strength equal to 5° Twaddel, and 1580 lbs. of good coke, and sold for 12*s. delivered.*

In the following series of valuations I shall assume coal tar to be worth 1*s.* 6*d.* per 100 lbs., equal to 33*s.* 7*d.* per ton; cannel tars at 1*s.* per 100 lbs., equal to 22*s.* 5*d.* per ton, that best coke is worth 6*d.* per 100 lbs.; and I shall value the ammoniacal liquor with the second tabular scale of prices.

The standard cannel produced 10,916 cubic feet of 22·7-candle gas, 1435 lbs. of coke, 201 lbs. of tar, and 65 lbs. of ammonia water, having a strength equal to 4° Twaddel, and cost 26*s.* delivered.

First, the coal—

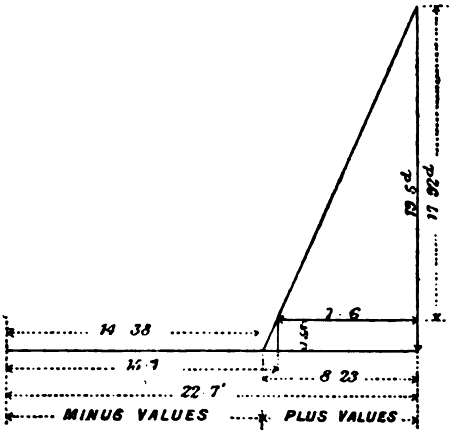
	s.	*d.*
1580 lbs. of coke, at 6*d.* per cental	7	11
120 lbs. of tar, at 1*s.* 6*d.* ,, ...	1	9½
141 lbs. of ammonia water × 0·756	1	0
Secondary products worth	10	8½

12*s.* *minus* 10*s.* 8½*d.* = 1*s.* 3½*d.* or 15·5*d.* $\frac{15\cdot5}{9\cdot81}$ = 1·58*d.* per 1000 for 15·1-candle gas.

Next, the cannel—

	s.	*d.*
1435 lbs. of coke, at 4*d.* per cental	5	4½
201 lbs. of tar. at 1*s.* „ „	2	0
65 lbs. of ammonia water × ·357*s.* per cental ..	0	3
	7	7½
Difference carbonizing, etc., expenses 10,916 – 9810	0	7
	8	2½

26*s.* *minus* 8*s.* 2½*d.* = 17*s.* 9½*d.* = 213*d.*, and $\frac{213}{10{,}916}$ = 19·5*d.*, which represents the value per 1000 of 22·7-candle gas. Now find the illuminating power which has a value equal to 0, which is found as follows: 19·5 – 1·58 = 17·92*d.*, and 17·92 : 7·6 : ; 19·5 : *x*, or 8·32, the 7·6 is found by subtracting 15·1 from 22·7. Then 22·7 *minus* 8·32 = 14·38, which in this case is the quality of gas whose value per 1000 = 0.



The above proportion stated for the triangular ratios, gives the results obtained, and marked in this diagram. Then

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[*] Had the value of the standard coal candles' value per 1000, after deducting the sum of the values of the secondary products been found to be a *minus*

$\frac{19\cdot5}{8\cdot32} = 2\cdot34d.$ will represent the rise in value for each increase of one candle in illuminating power on the ***plus*** side of origin, or the value for decreases on the ***minus*** side, and it is this constant only which we shall require to use in this system of valuation, whose logarithm is: Log. 2·34 = 0·3692159.

Example I.

A coal produces 7,400 cubic feet of 11·9-candle gas, 1650 lbs. of coke, 100 lbs. of tar, and 100 lbs. of ammonia water, having a strength equal to 4° Twaddel. ***Here the value of the gas is a minus value.***

14·38 candles
11·9 candles

2·48 × 2·34*d.* × 7·400

Log. 2·48 = 0·3944517
„ 2·34 = 0·3692159
„ 7·40 = 0·8692137

„ 42·943 = 1·6328993

	s.	*d.*
1650 lbs. of coke, at 5*d.* per cental	6	10½
100 lbs. of tar, at 1*s.* 6*d.* „ „	1	6
100 lbs. of ammonia water, at ·357*s.* per cental ..	0	4
	8	8½

---

value, as it might have been, had the selling price delivered been a few shillings less, then origin would be found by *subtracting* the number of candles x, which is found by using the following triangular ratios from the illuminating power of the cannel.

The money value in pence of the illuminating power of the standard cannel per 1000 + the money value in pence of the ***minus*** coal value per 1000; ***(in this case its sign is changed and is positive)*** : the difference between the illuminating power of the standard coal and cannel : : the value in pence of the standard cannel gas per 1000 : x, and the illuminating power of the cannel, ***minus*** x, will give the required distance, or the number of candles which are to be valued at ***minus*** values, and the distance to origin where the values begin to have ***plus*** values.

Difference carbonizing, etc., expenses, 7,400 − 9,810	2	3
Less gas, 43*d.*	3	7
	5	10
This coal is worth	2	10½

per ton when the standard coal sold for 12*s.*, and the standard cannel for 26*s.*

Example II.

A coal produces 9,115 cubic feet of 16·6-candle gas, 1498 lbs. of coke, 244 lbs. of tar, and 211 lbs. of ammonia water, having a strength equal to 4½° Twaddel.

16·6
14·38

2·20 × 2·34*d.* × 9·115

Log. 2·2 = 0·3424227
„ 2·34 = 0·3692159
„ 9·115 = 0·9597567

„ 46·924*d.* = 1·6713953

	s.	*d.*
Gas worth	3	11
14·98 lbs. of coke at 6*d.* per cental	7	6
244 lbs. of tar at 1*s.* 6*d.* „ „	3	8
211 lbs. of ammonia water × ·491 per cental	0	10
	15	11
Less carbonizing difference 9,810 − 9115	0	6
So this coal is worth	15	5

when the standard coal is worth 12*s.*, and the standard cannel is worth 26*s.*

Example III.

A cannel produces 8,370 cubic feet of 17·3-candle gas, 1330 lbs. of coke, 123 lbs. of tar, and 150 lbs. of ammonia water, having a strength equal to 4° Twaddel.

17·3
14·38

2·92 × 2·34 × 8·37

Log. 2·34 = 0·3692159
„ 2·92 = 0·4653829
„ 8·37 = 0·9227255

„ 57·19*d.* = 1·7573243

		s.	d.
Gas worth 57·19*d.*	=	4	9
13·30 lbs. of coke at 2*d.* per cental	=	2	2½
123 lbs. of tar at 1*s.* „ „	=	1	3
150 lbs. of ammonia water × ·357 per cental	=	0	6
		8	8½
Less difference carbonizing, etc., expenses 10·916 − 8·370	=	1	11
So this cannel is worth		6	9½

when the standard coal sells for 12*s.*, and the standard cannel for 26*s.*

EXAMPLE IV.

A cannel produces 12,500 cubic feet of 32-candle gas, 145 lbs. of tar, and 60 lbs. of ammonia water, having a strength equal to 4½° Twaddel and 1100 lbs. of coke.

32
14·38

17·62 × 2·34 × 12·5

Log. 2·34 = 0·3692159
„ 12·50 = 1·0969100
„ 17·62 = 1·2460059

„ 515·39*d.* = 2·7121318

	£.	s.	d.
Gas worth	2	2	11
1100 lbs. of coke at 2*d.* per cental	0	1	10
145 lbs. of tar at 1*s.* „ „	0	1	5½
60 lbs. of ammonia-water × ·491 per cental	0	0	2½
Carbonizing, etc., difference between 12·500 and 10·916	0	0	9
So this cannel is worth	£2	7	2

when the standard coal sells for 12*s.*, and the standard cannel for 26*s.*

EXAMPLE V.

A coal produces 9260 cubic feet of 16·7-candle gas, 1480 lbs. of coke, 183 lbs. of tar, and 231 lbs. of ammonia-water, having a strength equal to 4½° Twaddel.*

16·7
14·38
———
2·32 × 9·260 × 2·34*d.*

Log. 2·34 = 0·3692159
„ 2·32 = 0·3654880
„ 9·260 = 0·9666110
———
„ 50·271*d.* = 1·7013149

	s.	*d.*
Gas worth	4	2¼
1480 lbs. of coke at 6*d.* per cental	7	4¾
183 lbs. of tar at 1·5*s.* „ „	2	9
231 lbs. of ammonia water 4½° Twaddel at 0·491*s.*	1	1½
	15	5½
Difference, etc., carbonizing expenses 9260 – 9810	0	5½
So this coal is worth	15	0

when the standard coal sold for 12*s.*, and the standard cannel for 26*s.*

---

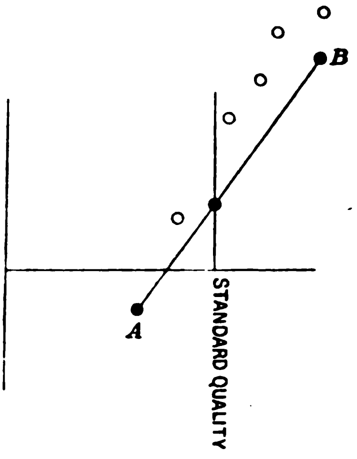
* This system of valuation may be applied to ascertain the loss arising from the use of stock coal. The price of removal from the stores to the retorts being added, in certain cases, to original cost, delivered, this stock coal, which had deteriorated with the low combustion to which it had been subjected, would be re-tested, and in the valuation this coal would be treated as if it were another material.

NAPHTHALINE.

I have not in any of these valuations taken notice of the tendency of gas produced from inferior qualities of coal (apart altogether from the influence of cold) to produce naphthaline ($C_{10} H_8$)—from the fact that coal and cannel gas both contain a considerable percentage of free hydrogen, it is not improbable that it may be increased by the decomposition of the heavy hydrocarbon constituents into naphtha and naphthaline, liberating free hydrogen. So also the "scurf," or retort carbon, may also represent the richer carbon deposits from the gas, liberating free hydrogen. Common coal gas deposits naphthaline, while cannel gas deposits naphtha—the combination of the two being a brown liquid—from the fact that naphthaline is soluble in naphtha; advantage may be taken of this property to clear mains of naphthaline, by passing cannel gas through them—the naphtha of the cannel gas dissolving the naphthaline crystals deposited from the coal gas, the two being removed by pumping in the street syphons. And since inferior qualities of common coal gas produce more naphthaline than the better qualities, a liberal discount from their values may safely be allowed for the coals producing inferior qualities of gas.

A GRAPHIC METHOD OF ASCERTAINING THE CHEAPEST MATERIALS (COAL AND CANNEL) FROM WHICH THE STANDARD QUALITY OF GAS CAN BE MANUFACTURED, FOLLOWS AS A COROLLARY FROM THE PRECEDING METHOD OF ASCERTAINING VALUES.

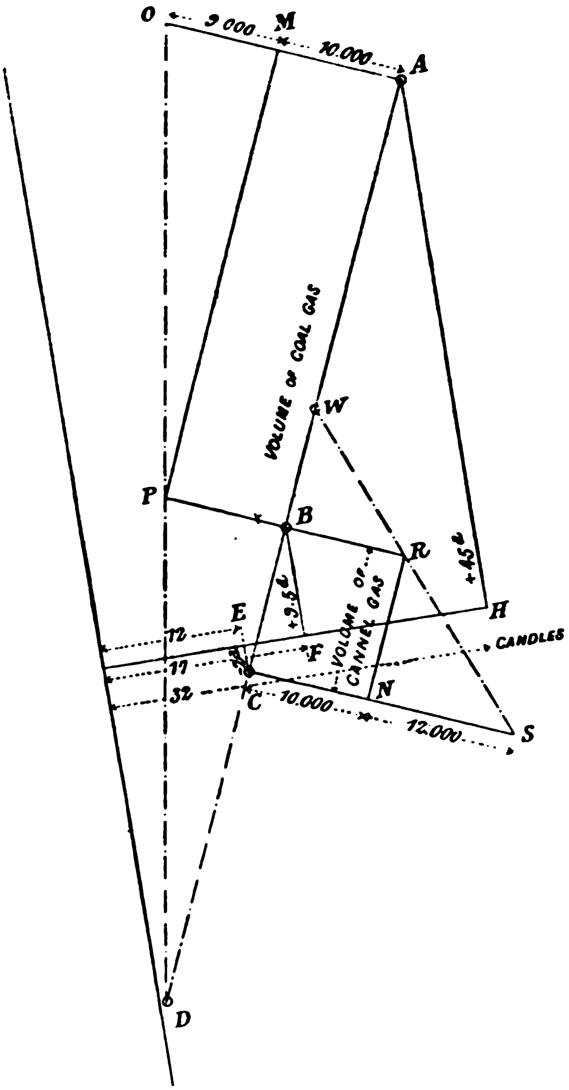
Corollary I.—Deduct the values of the secondary products, and the difference in the carbonizing, etc., etc., expenses from each of the prices delivered for which the material is offered for acceptance, and divide this value (value of gas produced) (−) or (+) by the make of that material, lay off co-ordinates representing these values (cost and illuminating power per 1000). Then the straight line A B, which cuts the standard quality line at the lowest point, is that from which that quality of gas can be made cheapest from among this selection of materials. (See fig. 10.)



Corollary II.—If the diagonal line A B be divided into 100 equal parts, the percentages of coal and cannel gas (volumes), requisite to make the required intermediate quality, may be read off from the inverse sides of the vertical line which cuts the diagonal one, or this percentage may be read off from the horizontal measurements, (the ratios being similar), of the vertical lines which pass through these points, or from a scale of 100 equal parts, the ends of which, if placed diagonally, will measure from the vertical lines passing through the coal and cannel illuminating powers; the percentages of each quality of these component gases, cut off by the vertical intermediate line—which read inversely—gives the percentages by volume necessary to manufacture that intermediate quality of gas.

Corollary III.—Arithmetically the same result and ratios may be obtained by subtracting the standard intermediate value from the illuminating power the coal and cannel separately produce; then will the sum of these differences be to any one of them, as 100 is to x, from which the percentages by volume may be obtained.

In a previous paper a similar method was used for obtaining the *weight* of the coal and cannel to be used; here it is used to obtain the *volume* of each of the constituent gases.


O
9.000
M
10.000
A
VOLUME OF COAL GAS
W
P
B
R
+45 d
+9.5 d
H
E
12
11
32
F
CANDLES
VOLUME OF CANNEL GAS
N
C
10.000
12.000
S
D

A GRAPHIC METHOD OF ASCERTAINING THE PERCENTAGES BY WEIGHT OF COAL OR CANNEL REQUISITE TO MAKE ANY QUANTITY OF GAS INTERMEDIATE TO THE QUALITY PRODUCED FROM THE STANDARD COAL AND CANNEL.

Let the ***minus*** value of 12-candle gas equal 2*d.* per 1000, and the plus value of 32-candle gas equal 45*d.* per 1000. Then graphically 17-candle gas will cost 9·5*d.* or 9½*d.* per 1000 in the materials, and by Corollary III., C A : 100 : : C B : *x*, or the percentage of 32-candle gas by volume requisite to be used in the mixture to produce 17-candle gas, or C A : 100 : : B A : *y*, or the percentage of 12-candle coal gas, by volume, required for this mixture.

Let the make of the coal equal 9000 cubic feet per ton, and the make of the cannel equal 12,000 cubic feet per ton.

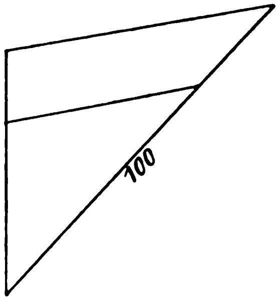
Lay off 10,000 at A and C from a diagonal scale to represent similar volumes per unit of length, at A M produced, lay off 9000 to represent the make of the coal, and at C N produced 12,000 to represent the make of the cannel.

Produce O P until it meets A C produced in D, and produce S R until it meets A C in W. Then if A C = 100, C B will equal the percentage by volume of 32-candle gas, and B A the percentage by volume of 12-candle gas requisite to manufacture 17-candle gas, and as rectangle O M × B D = M A × A B, and rectangle N S × B W = B C × C N (Euclid I. and 43d) which is, that if D W equal 100 tons, B W will equal the percentage of tons of cannel required producing 12,000 cubic feet of 32-candle gas to produce 17-candle gas from the mixture, and D B will equal the number of tons of coal producing 9000 cubic feet of 12-candle gas to produce 17-candle gas from the mixture.

D W : 100 : : D B (the coal) : *x* or its percentage by weight, or again,

D W : 100 : : B W (the cannel) : *y*, or its percentage by weight in the mixture.

By a well known practical geometrical method, it is easy to determine from any scale of equal parts these percentages by volume and weight. Thus, from either extremity of the lines to be measured, lay off a line making an angle with the line to be measured, cut off 100 parts by measurement on this line, connect the extremities of both, forming a triangle, and parallel to this line lay off a line passing through the intermediate fractional one. This line will cut the percentage line at the point where the percentages are to be read off on the scale.



PRACTICAL EXAMPLES OF A METHOD OF VALUING GAS COALS AND CANNELS, GRAPHICALLY AND ARITHMETICALLY, AFTER THE SYSTEM DESCRIBED IN COROLLARY I., PAGE 88.

It was originally my intention to have published this paper separately, along with a large engraved diagram, for the use of those who chose to resort to this system of valuation, which in some respects may be said to be the converse of the method already described and exemplified.

Although I have illustrated this system with the same series of examples I selected for the paper, beginning with page 81, I have not thought it advisable to abbreviate the estimates of the values of the secondary products, which will prevent the necessity and inconvenience of my readers referring to matter which is common to both papers, which will, I trust, render the manner and method of this system of valuation of easy comprehension.

In the following series of valuations I shall assume that the commercial values of the secondary products per cental are similar to those quoted in page 81.

In valuing after this system, it is requisite to have only one standard for comparison, which may be either a coal or cannel of fair average quality, as it is necessary to compare its make per ton with those carbonizing, repair, renewal, and interest charges entailed from the use of materials yielding less or greater quantities of gas per ton.

As I have before explained, when a coal or cannel yielding a larger quantity of gas than that used to represent the standard for comparison, a portion of the price paid is the equivalent of these charges paid to the colliery proprietor, in consideration of the superior productiveness of this material; on the other hand for inferior qualities valued after this method, this difference is *really added to cost price delivered*, and forms an element of cost of material, *as real*, as if this charge were added in by the colliery proprietor, he agreeing to meet these costs in manufacture. An example will render this reasoning more apparent.

The standard coal produces, say 10,000 cubic feet per ton. Another material produces 11,000 cubic feet per ton, the difference of the carbonizing, etc., charges (page 11) on these difference of makes equals 8*d.* If this coal were delivered for, say 13*s.* 8*d.* per ton, then the 8*d.* would represent the equivalent of these charges paid to the colliery proprietor in consideration for the extra 1000 cubic feet his material produced per ton. On the other hand if another material produced only 9000 cubic feet, the difference of these costs and charges would equal 8*d.* (see p. 11); and in this case, if this coal were delivered for 13*s.* per ton, this 8*d.* would have to be added on to the cost price *delivered* before a true comparison could be made with that quality which produced 10,000 cubic feet per ton.*

With these preliminary explanations I may now proceed to practically illustrate the method of its application by revaluing the coals valued in the paper beginning with p. 81.

EXAMPLE I.—STANDARD COAL.

A coal produces 9810 cubic feet of 15·1-candle gas, 120 lbs. of tar, 141 lbs. of ammonia water having a strength equal to 5° Twaddel, and 1580 lbs. of good coke, and sold for 12*s.* delivered.

	s.	*d.*
1510 lbs. coke at 6*d.* per cental	7	11
120 lbs. of tar at 1*s.* 6*d.* per cental	1	9½
141 lbs. of ammonia water × 0·756	1	0
Secondary products worth	10	8½

12*s.* − 10*s.* 8½*d.* = 1*s.* 3½*d.*, or 15·5*d.*, and $\frac{15\cdot5d.}{9\cdot81} = 1\cdot58d.$ per 1000 cubic feet for 15·1-candle gas, which two numbers represent the values of the co-ordinates which are to be laid off in the diagram which was the value of the cheapest coal in that series of valuations with which the others were compared.

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* It will be observed that although I have added the difference in the costs of carbonizing, interest, repairs, &c., to the price delivered for those coals and cannels which produce less gas per ton than the standard coal or cannel selected for standards for comparison, nevertheless this is afterwards deducted along with the value of the tar, coke, and ammoniacal liquor.

EXAMPLE II.

The standard cannel in that series produced 10,916 cubic feet of 22·7-candle gas, 1435 lbs. of coke, 201 lbs. of tar, 65 lbs. ammonia water, having a strength equal to 4° Twaddel, and costs 26*s.* delivered. The difference between the carbonizing, &c., expenses of a material yielding 9810 cubic feet, and one producing 10,916 equals 7*d.*, so that 26*s.* minus 7*d.*, or 25*s.* 5*d.*, really represented the cost price delivered, as the 7*d.* was paid to the colliery proprietor in consideration of the superior productiveness of his cannel, in lieu of wages, interest, cost of renewals and repairs, which would have had to have been incurred by the gas company as wages, &c., paid to the men, or for capital employed in retorts, &c., to work a material producing an inferior make.

The secondary products of this cannel are worth—

	s.	*d.*
1435 lbs. coke at 4*d.* per cental	5	4½
201 lbs. tar at 1*s.*	2	0
65 lbs. of ammonia water × ·357*s.*	0	3
	7	7½
Difference, carbonizing, &c., expenses	0	7
	8	2½

$$26s. - 8s.\ 2\tfrac{1}{2}d. = 17s.\ 9\tfrac{1}{2}d. = 213d. \text{ and } \frac{213}{10{,}916} = 19\cdot 5d., \text{ which}$$

Those charges (carbonizing, interest, repairs, &c.) were not for gas, but the outlay which met this difference in the costs of production; so that, for coals or cannels yielding a less production of gas per ton than that material selected for a standard of comparison, the plus or minus value of the gas produced would be equal to the price delivered, minus the sum of the value of secondary products. On the other hand, the value of these differences (carbonizing, interest, renewals, repairs, &c.) must be deducted from the price delivered for materials yielding volumes exceeding that produced from the coals or cannels selected for standards of comparison.

Again, it will be seen that interest for extra retorts, and retort house accommodation, is included in this difference, inasmuch as, if inferior coal or cannel be selected for use, this *excess* of interest for use of capital must necessarily increase the cost price of gas to consumer; *not because* he pays the interest on *a necessary expenditure*, but because this addition to costs is an unnecessary charge, had better and more productive material been selected for the manufacture of the gas.

represents the cost per 1000 of this 22·7-candle gas, these being the values of the co-ordinates of the standard cannel gas per 1000.

Example III.—*Marked I. in p.* 83.

A coal produces 7,400 cubic feet of 11·9-candle gas, 1650 lbs. of coke, 100 lbs. of tar, and 100 lbs. of ammonia water having a strength equal to 4° Twaddel, and cost 13*s.* 6*d.* delivered.

Difference, carbonizing, &c., expenses, 7,400 – 9,810 = 2*s.* 3*d.*; *so that really* this coal costs 13*s.* 6*d.* + 2*s.* 3*d.* = 16*s.* *delivered*, as it cost the extra 2*s.* 3*d.* to work it, as compared with the better article producing 9,810, and costing 12*s.* delivered.

	s.	*d.*
1650 lbs. of coke at 5*d.* per cental	6	10½
100 lbs. of tar at 1*s.* 6*d.* per cental	1	6
100 lbs. of ammonia water at ·357	0	4
	8	8½
Difference, carbonizing expenses, 7,400 – 9,810 ..	2	3
	10	11½

and 16*s.* – 10*s.* 11½*d.* = 5*s.* 0½*d.* or 60·5*d.*

Log. 60·5*d.* = 1·7817554
„ 7·4000 = 0·8692317

„ 8·1757 = 0·9125237

so that this 11·9-candle gas costs 8·1757*d.* per 1000, which figures are the co-ordinates to be used in the diagram.

Example IV.—*or II. in p.* 84.

A coal produces 9,115 cubic feet of 16·6-candle gas, 1498 lbs. of coke, 244 lbs. of tar, and 211 lbs. of ammonia water having a strength equal to 4½° Twaddel, and costs 16*s.* delivered.

Difference in carbonizing, &c., expenses, between coal yielding 9810 and 9115 cubic feet equals 6*d.*, so that this coal nearly costs 16*s.* 6*d.* delivered.

	s.	d.
1498 lbs. of coke at 6*d.* per cental	7	6
244 lbs. of tar at 1*s.* per cental	3	8
211 lbs. of ammonia water × ·491 per cental ..	0	10
	12	0
Carbonizing, &c., differences between 9810 − 9115	0	6
	12	6

and 16*s.* 6*d.* − 12*s.* 6*d.* = 4*s.* = 48*d.*

Log. 48*d.* = 1·6812412
Log. 9·115 = 0·9597567

Log. 5·266 = 0·7214845

so that this 16·6-candle gas costs 5·266*d.* per 1000, the values of the required co-ordinates.

EXAMPLE V.—*or No. III., p.* 84.

A cannel produces 8,370 cubic feet of 17·3-candle gas, 1330 lbs. of coke, 123 lbs. of tar, and 150 lbs. of ammonia water having a strength equal to 4° Twaddel, and costs 17*s.* 6*d.* delivered.

This cannel produces 8,370 cubic feet, while the standard coal produced 9,810 cubic feet, a difference against this cannel equal to 1*s.* 3*d.* per ton, making its real cost equivalent to 18*s.* 9*d.* per ton as compared with that of the standard coal.

	s.	d.
1330 lbs. of coke at 2*d.* per cental	2	2½
123 lbs. of tar at 1*s.* per cental	1	3
150 lbs. of ammonia water × ·357	0	6
	3	11½
Difference, carbonizing, &c., expenses 8370 and 9810	1	3
	5	2½

18·9 − 5*s.* 2½*d.* = 13*s.* 6½*d.* or 162·5*d.*

Log. 162·5*d.* = 2·2108534
Log. 8·370 = 0·9227225

Log. 19·415 = 1·2881309

So that this 17·3-candle gas costs 19·415*d.* per 1000 cubic feet, which values represent the co-ordinates to be laid off on the diagram.

EXAMPLE VI.—*that is IV., p.* 85.

A cannel produces 12,500 cubic feet of 32-candle gas, 145 lbs. of tar, and 60 lbs. of ammonia water having a strength equal to 4½° Twaddel, and 1100 lbs. of coke, and this cannel cost £2 10*s.* delivered.

The difference between the carbonizing, &c., expenses, 12,500 − 9810 equals 1*s.* 5*d.*

	s.	*d.*
1100 lbs. of coke at 2*d.* per cental	1	10
145 lbs. tar at 1*s.* per cental	1	5½
60 lbs. ammonia water × ·491	0	2½
Difference, carbonizing, &c., expenses, 9810 − 12,500	1	5
	4	11

£2 10*s.* − 4*s.* 11*d.* leaves £2 5*s.* 1*d.* to represent the cost of the gas, = 541*d.*

$$\begin{aligned} \text{Log. } \underline{541d.} &= 2\cdot7331973 \\ \text{Log. } 12{,}500 &= \underline{1\cdot0969100} \\ \text{Log. } 43\cdot28 &= 1\cdot6362873 \end{aligned}$$

So that this 32-candle gas costs 43·28*d.* per 1000, which two values gives the required ordinates.

EXAMPLE VII.—*that is No. V. in p.* 86.

A coal produces 9260 cubic feet of 16·7-candle gas, 1480 lbs. of coke, 183 lbs. of tar, and 231 lbs. of ammonia water having a strength equal to 4½° Twaddel, and costs 16*s.* delivered.

This coal produces only 9260 cubic feet, while the standard coal produced 9810. The differences in carbonizing, &c., expenses corresponding to these numbers equals 5*d.*, so that this coal really costs 16*s.* 5*d.* delivered.

	s.	*d.*
1480 lbs. of coke at 6*d.* per cental	7	4½
183 lbs. of tar at 1·5*s.*	2	9
231 lbs. of ammonia water, 4½° Twaddel, at 0·491*s.*	1	1½
Difference, &c., carbonizing expenses between 9810 and 9260	0	5
	11	8

16*s.* 5*d.* − 11*s.* 8*d.* = 4*s.* 9*d.*, or 57*d.*

Log. 57*d.* = 1·7558749
Log. 9260 = 0·9666110

Log. 6·1555 = 0·7892639

So that this 16·7-candle gas cost 6·1555*d.* per 1000 cubic feet, which gives the co-ordinates.

In Fig. 15 I have laid off these co-ordinates as they would be laid off on an enlarged diagram such as I propose to have published shortly, marking the results obtained by this system of ascertaining the values of the various qualities of gas per 1000 with a ⊙, and showing the comparative values as ascertained by the previously described method, thus ●, so that both methods are delineated in the same diagram.

Suppose the quality of gas to be manufactured was 17-candle gas, then it could be made cheapest from Nos. 1 and 2, and, as measured graphically, would cost 6½*d.* in the material, independent of the cost of labour, profit, and those charges which in the aggregate made up cost price per 1000 at the station meter.

On the other hand, if this 17-candle gas were made from mixtures of No. 3 and 5, the cost of the gas per 1000 at the station meter in the material, with nothing expended for labour, &c., would graphically equal 18·5*d.*, a difference equivalent to 1*s.* per 1000 at the station meter. Nor are these ideal values; they were the prices current for these materials at a certain date and place. These *possible* differences in costs amounting to 12*d.*, a sum sufficient to add from four to five candles to the illuminating power of the gas if made from more judiciously selected materials. On the other hand, it will be but too apparent, how difficult it may be in certain cases to make ends meet, unless illuminating power is sacrificed to prevent the loss which must necessarily arise from the use of inferior and high-priced materials.

It is this graphic system which should be used first to discover from what materials the gas can be made cheapest, and from this, by means of formulae and methods already described and illustrated, to ascertain the comparative commercial values of all other qualities of gas produced from the coals or cannels submitted for approval and purchase.

I propose shortly to have issued an engraved diagram suitable for ascertaining these values graphically, which will enable this system to be more expeditiously applied than if each of these co-ordinates had to be drawn on paper.

And now I shall draw these papers to a conclusion. In them I have treated of gas-making from a geometrical and mathematical basis. If the premises in the introduction are a reasonable statement of facts, and the methods afterwards pursued, together with the deductions drawn from them, be the legitimate inferences deduceable from the inductive introduction, leading up in the final papers to a simple and easily applied system of valuation, then I may not altogether have laboured in vain. Trusting this system of valuation may at times be found serviceable to those requiring the use of such methods of valuing, that it will bear the test of experience, and the scrutiny of those who are most capable of judging its merits or demerits, I now take leave of the subject, and bring my labours to a close.

FINIS.

NAME OF COAL OR CANNEL.	Return Per Ton.	Quality of Gas, Sugg's N.L B.	Quantity of Coke duced in Lbs.	Per Centage of Ash in Coke.	Weight of Tar in Lbs.	Weight of Amn Water in Lbs.	Strength of Amn Water in Deg. T dle.	Pounds of Lim quired to purify produced from Ton of Coal or Ca	NAME OF TESTER.
West Yorkshire Coal and Iron Co.'s Cannel .	10·333	21·3	1350	15 p. c.	216	150	4·2	..	D. A. Graham. These averages have been obtained in nearly every case from twenty tests or upwards.
Wigan Coal and Iron Co.'s Coal.	10·060	17·3	1500	..	170	180	5·1	80	"
Rhodes and Dalby's Coal	8·793	16·1	1380	..	143	308	3·3	..	"
Silkstone Fall	9·560	16·4	1530	..	141	200	4·8	74·4	"
G——'s L——e H——n, near Manchester . .	7·400	11·91	1650	..	..	..	..	..	"
Chatterly Coal and Iron Co.'s Shale . . .	12·000	15·23	1400	..	25·28 gal.	..	..	..	"
Dukinfield Cannel	10·916	22·7	1435	..	201	65	4 deg.	91	"
Duke of Bridgewater's Cannel	9·676	20·3	1460	..	240	105	5·4	..	"
Picked	10·190	..	..	..	..	..	..	..	"
Nottingham Cannel	8·370	17·3	1330	..	123	150	..	..	"
Rhodes Wright and Wroe's Coal	9·200	14·9	1565	..	145	125	4 deg.	..	"
Duke of Bridgewater's Coal (unscreened) .	8·820	14·25	1500	..	140	180	3.6	..	"
Albert Colliery, near Chesterfield (unscreened)	9·155	16·6	1498	..	244	211	..	96	"
Silkstone Small	7·260	15·1	1545	..	130	165	..	..	"
Ellis Lever's Eckington's	9·720	17·4	740 to 1200	*	150	190	5 deg.	..	"
Copper House Burgy, near Oldham . . .	9·240	17·3	1550	14 p. c.	176	183	5 deg.	..	"
Black Mine Sound Coal, Dunkirk	10·150	17·2	1540	..	175	155	5·5	..	"
Hanley and Bucknall	9·260	16·7	1480	..	183	231	4·3	..	"
Broad Oak Sound Coal, near Ashton . . .	10·260	17·3	1380	..	140	190	5·5	..	"
Wood Park Broad Oak Small (Burgy) . . .	9·118	15·6	1560	..	130	145	6 deg.	..	"
Saul Isaac's Clifton Cannel	10·120	19·4	1170	..	210	390	..	..	"
Another Average of Testings	9·810	18·2	..	..	..	..	..	..	"
Limehurst Coal Co.'s Sound, near Ashton . .	10·820	17·4	1530	14	178	151	6 deg.	78	"
Limehurst Unscreened	9·810	15·1	1580	14	120	141	..	..	"
Prince of Wales Colliery, Pontefract . . .	9·660	20·2	1210	8	209	240	..	..	"
" " " . . .	9·816	19·81	1276	7·6	..	..	..	..	Professor Atfield, F.C.S.
" " " . . .	10·046	16·79	1316	..	..	..	..	..	T. M. Rimmington, Esq., Bradford.
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Dukinfield Cannel	11·250	22·5	1528	..	..	..	..	..	" " "

* Varies with percentage of coal and cannel in the mixture. The cannel coke contains 18 per cent. of ash, and the coal coke contains 9·5 per cent. of ash.

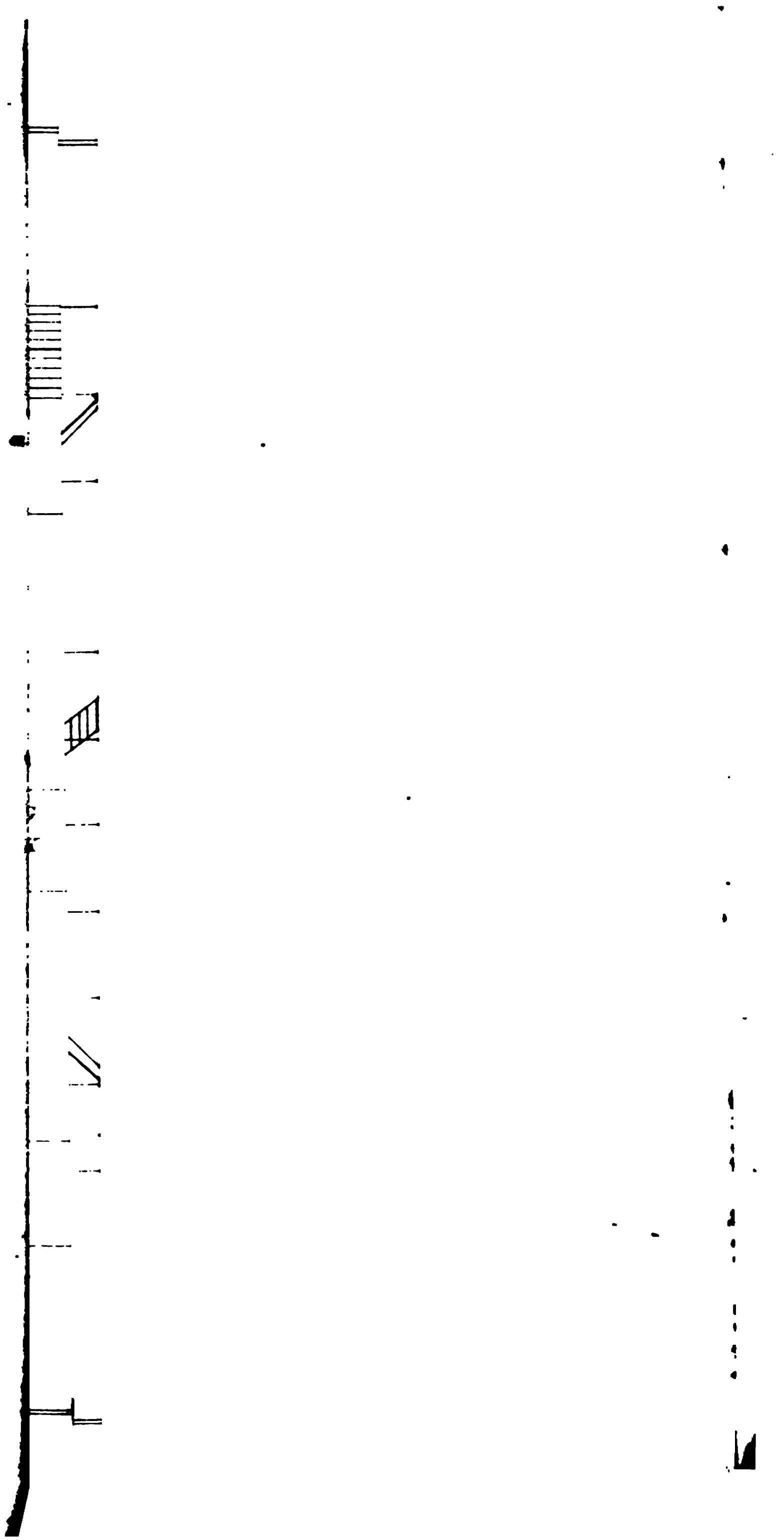
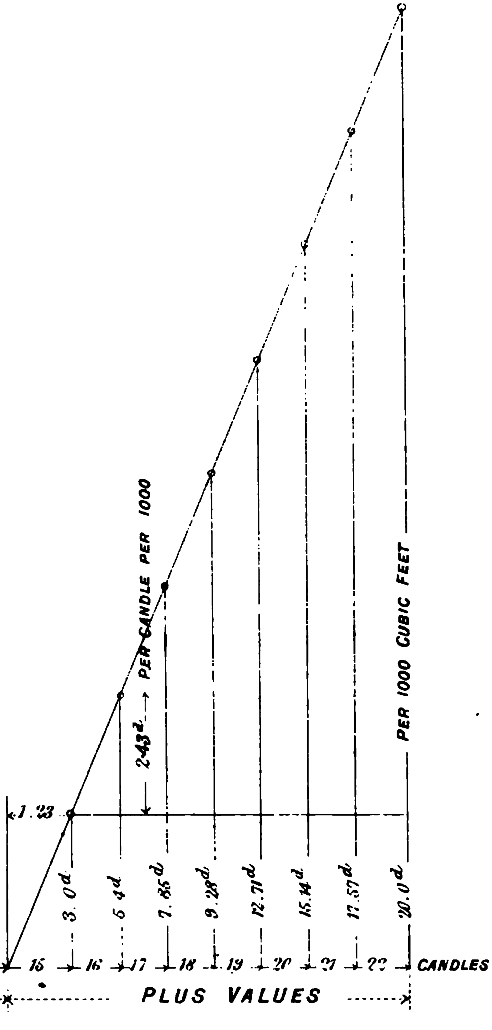


Plate 2.

8.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2.43d → PER CANDLE PER 1000
PER 1000 CUBIC FEET
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5.4d
7.85d
9.28d
12.71d
15.14d
17.57d
20.0d
15
16
17
18
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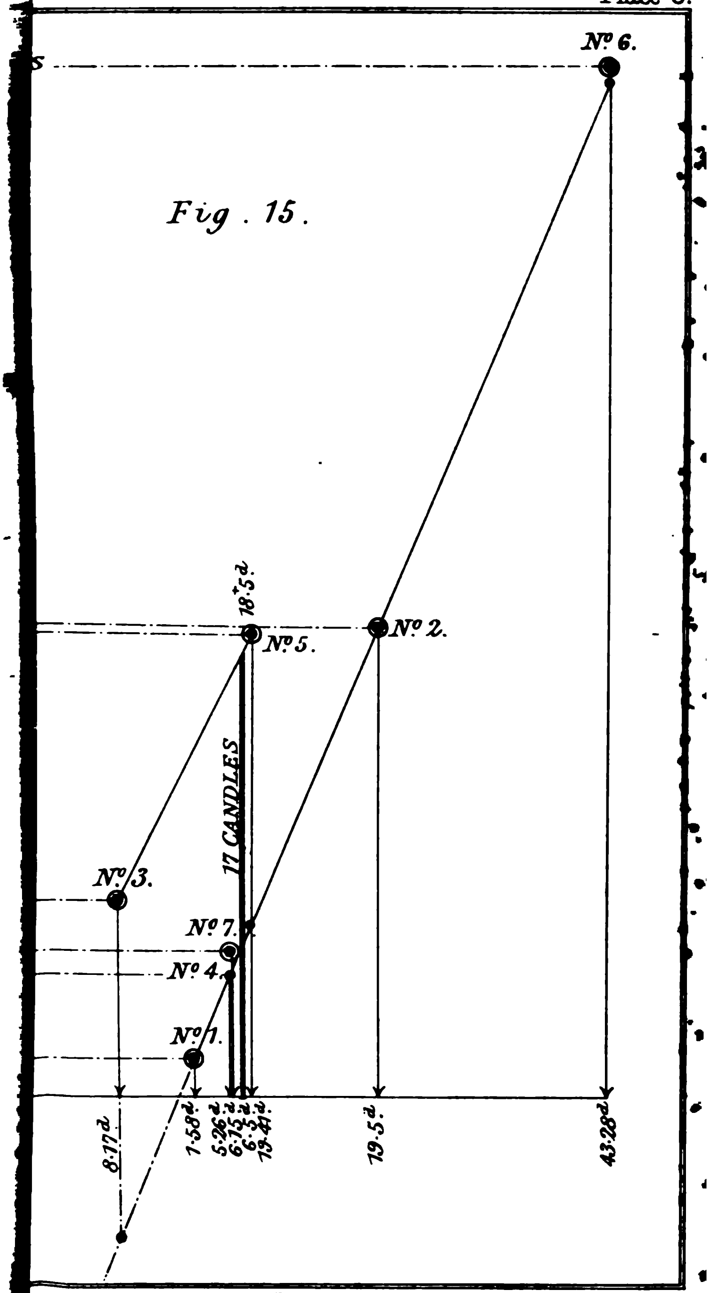

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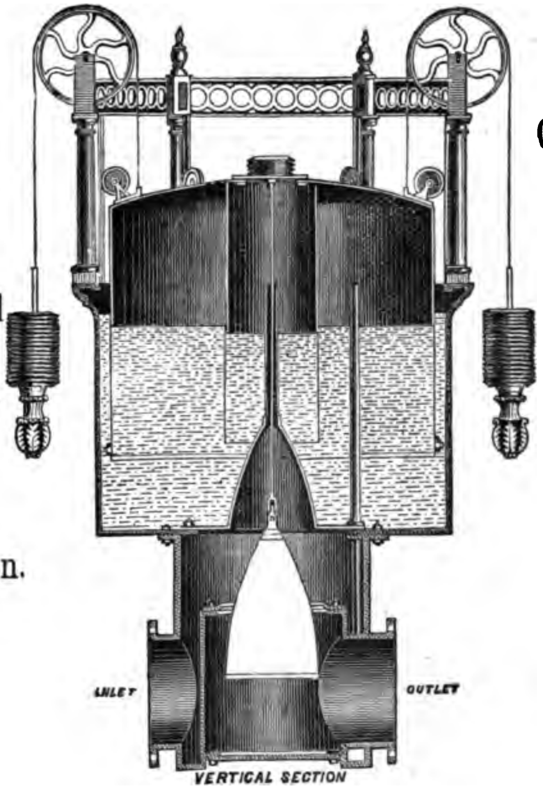

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